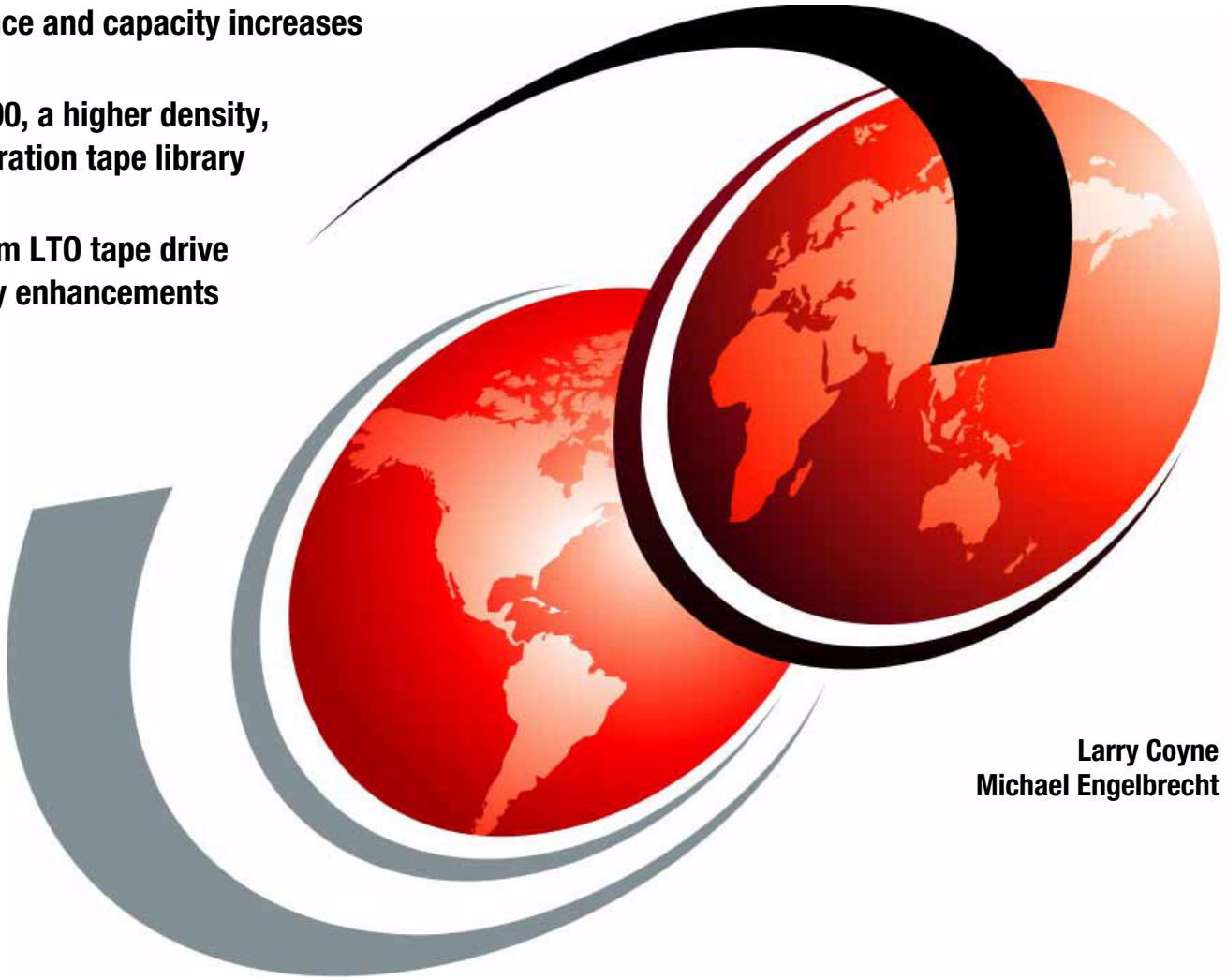
IBM

IBM Tape Library Guide for Open Systems

- IBM TS1150 enterprise tape drive performance and capacity increases
- IBM TS4500, a higher density, next-generation tape library
- IBM Ultrium LTO tape drive and library enhancements



Larry Coyne
Michael Engelbrecht

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IBM Tape Library Guide for Open Systems

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Eleventh Edition (February 2015)

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Contents

Notices xiii
Trademarks xiv

IBM Redbooks promotions xv

Preface xvii
Authors xvii
Now you can become a published author, too xviii
Comments welcome xix
Stay connected to IBM Redbooks xix

Summary of changes xxi
February 2015, Eleventh Edition xxi
June 2013, Tenth Edition xxi
June 2012, Ninth Edition xxii
June 2011, Eighth Edition xxiii
September 2008, Seventh Edition xxiii
October 2007, Sixth Edition xxiv
April 2007, Fifth Edition xxiv
September 2005, Fourth Edition xxiv
June 2004, Third Edition xxv
June 2003, Second Edition xxv
November 2000, First Edition xxv

Part 1. Tape basics of open systems 1

Chapter 1. Tape technology introduction 3
1.1 Introduction 4
1.2 Timeline 5
1.3 Tape products and technologies 6
1.3.1 Recording technology 7
1.3.2 Tape reels 8
1.3.3 Quarter-inch cartridge 9
1.3.4 Digital Data Standard 10
1.3.5 The 8 mm format 11
1.3.6 SuperDLT 14
1.3.7 IBM 3850 15
1.3.8 IBM 3480 16
1.3.9 IBM 3490 16
1.3.10 IBM 3590 17
1.3.11 LTO Ultrium tape 19
1.3.12 IBM TS1100 tape drive family 20
1.3.13 Libraries 22
1.4 Tape solutions in a SAN environment 27
1.5 Tape virtualization for open systems 28
1.5.1 ProtecTIER virtual tape 29
1.5.2 Data deduplication 29
1.5.3 HyperFactor 31
1.5.4 File System Interface 31

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1.5.5 ProtecTIER models . . . 31
1.6 Linear Tape File System . . . 33
1.6.1 LTFS Single Drive Edition . . . 34
1.6.2 LTFS Library Edition . . . 34
1.6.3 IBM Linear Tape File System Enterprise Edition (EE) . . . 36
1.6.4 LTFS Storage Manager . . . 37
1.7 IBM Tape System Library Manager . . . 38

Chapter 2. Overview of IBM LTO Ultrium tape drives . . . 41
2.1 The LTO organization . . . 42
2.1.1 Overview . . . 42
2.1.2 LTO standards . . . 45
2.1.3 Data compression . . . 47
2.1.4 Tape cartridge . . . 48
2.1.5 IBM LTO Ultrium common subassembly drive . . . 55
2.2 Tape encryption overview . . . 67
2.2.1 IBM Security Key Lifecycle Manager . . . 68
2.2.2 Encryption methods . . . 69
2.2.3 LTO Ultrium tape encryption . . . 71
2.3 IBM Ultrium 1, 2, 3, 4, 5, and 6 highlights . . . 72
2.3.1 IBM Ultrium 1, 2, 3, 4, 5, and 6 compatibility . . . 72
2.3.2 LTO performance . . . 73
2.3.3 Reliability . . . 76
2.4 IBM LTO Ultrium 6 tape drives . . . 78
2.4.1 The IBM LTO Ultrium 6 tape drive range . . . 81
2.5 IBM LTO Ultrium 5 tape drives . . . 85
2.5.1 The IBM LTO Ultrium 5 tape drive range . . . 88
2.6 IBM LTO Ultrium 4 tape drives . . . 92
2.6.1 The IBM LTO Ultrium 4 tape drive range . . . 95
2.6.2 The IBM LTO Ultrium family of tape drives and libraries . . . 99
2.6.3 Multipath architecture . . . 102
2.6.4 Next-generation multipath architecture . . . 104

Chapter 3. IBM TS1100 tape drives . . . 105
3.1 IBM TS1100 tape drive family . . . 106
3.1.1 The 1 TB background . . . 106
3.1.2 Nomenclature . . . 107
3.2 Common characteristics of the 3592 tape drive family . . . 107
3.2.1 Technology enhancements . . . 107
3.2.2 Recording format . . . 108
3.2.3 Reliability and availability . . . 109
3.2.4 Features designed for capacity and performance . . . 111
3.2.5 Performance or capacity scaling . . . 113
3.3 Physical attachment . . . 115
3.3.1 Multiple Fibre Channel ports . . . 115
3.3.2 Supported topologies . . . 116
3.4 Media . . . 116
3.4.1 3592 media cartridge . . . 117
3.4.2 WORM functionality . . . 121
3.4.3 Tape encryption for TS1120, TS1130, TS1140, and TS1150 . . . 123
3.5 IBM TS1150 tape drive . . . 124
3.5.1 Physical attachment . . . 126
3.5.2 Media . . . 126

3.5.3 Capacity and performance 127
3.5.4 Access performance specifications and drive characteristics 133
3.5.5 Emulation 134
3.5.6 Linear Tape File System (LTFS) partitioning support 134
3.5.7 Data safe mode 136
3.5.8 Enhanced Ethernet support 137
3.5.9 TS1150 physical characteristics 137
3.5.10 Upgrade considerations 140
3.5.11 Firmware updates 140
3.5.12 RAS 141
3.5.13 Improved media SARS 141
3.5.14 Encryption 142
3.6 IBM TS1140 tape drive 142
3.6.1 Physical attachment 144
3.6.2 Media 144
3.6.3 Capacity and performance 145
3.6.4 Access performance specifications and drive characteristics 148
3.6.5 Emulation 149
3.6.6 LTFS partitioning support 149
3.6.7 Data safe mode 150
3.6.8 Enhanced Ethernet support 150
3.6.9 TS1140 physical characteristics 150
3.6.10 Upgrade considerations 152
3.6.11 Firmware updates 152
3.6.12 RAS features 152
3.6.13 Improved media SARS 153
3.6.14 Encryption 153
3.6.15 Tracking data written 153
3.7 IBM TS1130 tape drive 153
3.7.1 Multiple subsystem and automation support 155
3.7.2 Media 155
3.7.3 Capacity and performance 156
3.7.4 Access performance specifications and drive characteristics 158
3.7.5 Emulation mode 159
3.7.6 TS1130 physical characteristics 159
3.7.7 Upgrade considerations 160
3.7.8 Firmware updates 160
3.7.9 RAS features 161
3.7.10 Improved media SARS 161
3.7.11 Encryption 161
3.7.12 Tracking data written 161
3.8 IBM TS1120 tape drive 162
3.8.1 Features for reliability, availability, and performance 163
3.8.2 Performance scaling and segmentation 165
3.9 IBM TotalStorage Enterprise tape drive 3592 Model J1A 165
3.9.1 Characteristics 166
3.9.2 Performance scaling 166

Chapter 4. IBM TS2260 tape drive 167
4.1 Product description 168
4.2 Half-High Ultrium 6 tape drive 169
4.2.1 Platform support 170
4.2.2 Performance highlights 170

4.3 Media 171
4.3.1 Data cartridges 171
4.3.2 Write Once Read Many cartridges 171
4.3.3 Cleaning cartridges 172
4.3.4 Cartridge memory 172
4.4 Encryption 172
4.5 Linear Tape File System 173
4.6 Physical attachment 173
4.6.1 Serial-attached SCSI 173
4.6.2 Single serial-attached SCSI and USB port 174
4.7 Specifications 175
4.7.1 Physical specifications 175
4.7.2 Power specifications 175
4.8 Feature codes 176

Chapter 5. IBM TS2360 tape drive 177
5.1 Product description 178
5.2 Full-High Ultrium 6 tape drive 179
5.2.1 Platform support 180
5.2.2 Performance highlights 181
5.3 Media 182
5.3.1 Data cartridges 182
5.3.2 Write Once Read Many cartridges 182
5.3.3 Cleaning cartridges 183
5.3.4 Cartridge memory (LTO-CM) 183
5.4 Encryption 183
5.5 Linear Tape File System 183
5.6 Physical attachment 184
5.6.1 Serial attached SCSI 184
5.7 Specifications 185
5.7.1 Physical specifications 185
5.7.2 Power specifications 185
5.8 Feature codes 185

Part 2. IBM tape libraries for open systems 187

Chapter 6. IBM TS2900 tape autoloader 189
6.1 Product description 190
6.2 TS2900 tape autoloader components 192
6.2.1 Operator Control Panel 193
6.2.2 Robotics 194
6.2.3 Bar code reader 194
6.2.4 Cartridge storage 194
6.3 IBM LTO Ultrium Half-High tape drives 195
6.3.1 LTO-6 Half-High tape drive 195
6.3.2 Encryption 196
6.3.3 Linear Tape File System 197
6.3.4 Notifications 198
6.4 Physical attachments 198
6.4.1 SAS interface 198
6.5 Media 198
6.5.1 Data cartridges 199
6.5.2 Write Once Read Many cartridges 199
6.5.3 Cleaning cartridges 199

6.5.4 Cartridge Memory chip 200
6.6 Specifications 200
6.6.1 Physical specifications 200
6.6.2 Power specifications 200
6.7 Feature codes 201

Chapter 7. IBM TS3100 tape library 203
7.1 Product description 204
7.1.1 TS3100 tape library Ultrium 6 models 205
7.1.2 TS3100 tape library Ultrium 5 models 206
7.1.3 TS3100 tape library Ultrium 4 models 206
7.2 TS3100 tape library components 207
7.2.1 Operator control panel 209
7.2.2 Robotics 210
7.2.3 Bar code reader 210
7.2.4 Cartridge storage 211
7.3 IBM LTO Ultrium tape drives 213
7.3.1 Ultrium 6 tape drives 213
7.3.2 Path failover 215
7.3.3 Encryption 215
7.3.4 Linear Tape File System 216
7.3.5 Notifications 217
7.4 Physical attachments 217
7.4.1 Fibre Channel interface 217
7.4.2 SAS interface 218
7.5 Media 219
7.5.1 Data cartridges 219
7.5.2 Cleaning cartridges 220
7.5.3 Cartridge memory chip 221
7.6 Specifications 221
7.6.1 Physical specifications 221
7.6.2 Power specifications 221
7.7 Feature codes 222

Chapter 8. IBM TS3200 tape library 225
8.1 Product description 227
8.1.1 TS3200 tape library Ultrium 6 models 228
8.1.2 TS3100 tape library Ultrium 5 models 228
8.1.3 TS3200 tape library Ultrium 4 models 229
8.2 TS3200 tape library components 230
8.2.1 Operator Control Panel 232
8.2.2 Robotics 233
8.2.3 Bar code reader 233
8.2.4 Cartridge storage 234
8.3 IBM LTO Ultrium tape drives 236
8.3.1 Ultrium 6 tape drives 236
8.3.2 Path failover 238
8.3.3 Encryption 238
8.3.4 Linear Tape File System 239
8.3.5 Notifications 239
8.4 Physical attachments 240
8.4.1 Fibre Channel interface 240
8.4.2 SAS interface 241

8.5 Media 242
8.5.1 Data cartridges 242
8.5.2 Cleaning cartridges 243
8.5.3 Cartridge memory chip 243
8.6 Specifications 243
8.6.1 Physical specifications 243
8.6.2 Power specifications 244
8.7 Feature codes 244

Chapter 9. IBM TS3310 tape library 247
9.1 Product description 248
9.1.1 TS3310 tape library Model L5B (Machine Type 3576) 249
9.1.2 TS3310 tape library Model E9U (Machine Type 3576) 250
9.2 Library expansion 251
9.3 Front panel components 253
9.3.1 Expansion module 254
9.3.2 I/O station 255
9.3.3 Access door 255
9.3.4 Operator panel 255
9.3.5 Power button 255
9.3.6 Front panel LEDs 255
9.4 Rear panel components 256
9.4.1 Library Control Blade 256
9.4.2 Tape drives 257
9.4.3 Power supply 258
9.5 Interior components 259
9.5.1 Storage columns 259
9.5.2 Robotic system 259
9.6 Optional features 260
9.6.1 IBM Ultrium tape drives 260
9.6.2 Redundant power supply 261
9.6.3 Feature licenses 261
9.7 Library management 263
9.7.1 Operator panel 263
9.7.2 Web user interface 265
9.7.3 Command-line interface 271
9.7.4 Native SMI-S support 272
9.7.5 Support for IBM Tivoli Storage Productivity Center 272
9.7.6 Advanced Reporting 274
9.7.7 Encryption 277
9.8 Multipath architecture 278
9.8.1 Using multiple logical libraries for library sharing 279
9.8.2 Using multiple control paths 279
9.8.3 Using multiple control paths for Control Path Failover 279
9.8.4 Using multiple data paths for Data Path Failover 280
9.9 Working with logical libraries 280
9.9.1 Automatically creating logical libraries 281
9.9.2 Manually creating logical libraries 281
9.9.3 Deleting logical libraries 282
9.9.4 Changing logical library access 282
9.9.5 Changing logical library modes 282
9.10 Supported environments 283
9.10.1 Supported server platforms 283

9.10.2 Supported operating systems 283
9.10.3 Supported storage software 284
9.11 Specifications 285
9.11.1 Timings 285
9.11.2 Physical specifications 285
9.11.3 Operating environment 285
9.12 Feature codes 286
9.12.1 Power cords 287
9.13 Publications 288

Chapter 10. IBM TS3500 tape library 289
10.1 Product description 291
10.1.1 TS3500 tape library frames for IBM LTO Ultrium Fibre Channel drives 294
10.1.2 TS3500 tape library frames L23 and D23 297
10.1.3 TS3500 tape library storage only frames S24 and S54 300
10.1.4 TS3500 tape library (3584) High Availability Unit HA1 304
10.1.5 TS3500 tape library Shuttle Complex (Model SC1) 306
10.1.6 High Performance Storage System. 317
10.1.7 Tape System Library Manager 319
10.2 Library components. 322
10.2.1 Tape drives supported in the TS3500 tape library 323
10.2.2 Library control systems 326
10.2.3 Operator interface 329
10.2.4 Robotic cartridge accessor 330
10.2.5 Rail assembly 333
10.2.6 Library-centric WWNN convention 333
10.2.7 Control path failover 333
10.2.8 Data Path Failover 335
10.3 Tape Library Specialist Management Interface. 335
10.3.1 Reliability. 337
10.3.2 Remote support 338
10.3.3 Monitor and report. 341
10.3.4 Adding and removing cartridges 344
10.4 Performance 344
10.4.1 Elements that contribute to high-performance capabilities 344
10.5 Upgrades and optional features 346
10.6 Advanced Library Management System 346
10.6.1 Functional description 347
10.6.2 Virtual I/O 351
10.7 Host platforms and device drivers. 353
10.7.1 Feature codes 353
10.8 Storage applications 353
10.9 Specifications 354
10.9.1 Physical specifications 354
10.9.2 Floor requirements 355
10.9.3 Operating environment 355
10.9.4 Power and cooling specifications 356

Chapter 11. IBM TS7600 ProtecTIER Systems 357
11.1 Terminology 359
11.1.1 The TS7650G gateway 359
11.1.2 The TS7650 Appliance 360
11.1.3 The TS7620 ProtecTIER Deduplication Appliance Express (3959 SM2) 360

11.2 Data deduplication 363
11.2.1 Virtual tape library concept 364
11.2.2 File System Interface concept 365
11.2.3 HyperFactor 366
11.3 TS7650G ProtecTIER Deduplication Gateway 367
11.3.1 TS7650G Gateway Models 367
11.3.2 TS7650G ProtecTIER Deduplication Gateway (3958 DD5) 368
11.3.3 Disk array 370
11.3.4 Deployment 370
11.4 TS7650 ProtecTIER Deduplication Appliance 375
11.4.1 TS7650 Deduplication Appliance 376
11.4.2 TS7650 ProtecTIER Deduplication Appliance features 376
11.4.3 Available models 376
11.4.4 Deployment 377
11.5 TS7620 ProtecTIER Deduplication SMB Appliance 379
11.5.1 TS7620 hardware components 379
11.5.2 Deployment 382
11.6 ProtecTIER VTL 383
11.6.1 ProtecTIER VTL concepts 384
11.6.2 Steady state 384
11.7 ProtecTIER OpenStorage 385
11.8 ProtecTIER FSI 387
11.8.1 FSI Replication 388
11.9 Initial configuration of TS7600 388
11.9.1 Initial configuration of TS7620 appliance 389
11.9.2 Initial configuration of the TS7650 gateway 390
11.10 ProtecTIER Manager 390
11.10.1 ProtecTIER native replication Management Interface 393
11.11 Set up the virtual library and cartridges 394
11.11.1 Creating libraries 394
11.12 ProtecTIER SNMP support 395
11.12.1 IBM MIB definition file 395
11.12.2 SNMP compatibility 396
11.13 Replication overview 397
11.14 How it works 398
11.14.1 Replication features 398
11.14.2 Typical deployment 401
11.15 ProtecTIER native replication 402
11.15.1 Replication licensing 402
11.15.2 Hardware 403
11.15.3 Replication grid 404
11.16 Normal operation concepts 405
11.16.1 Replication 405
11.16.2 Replication data transfer 406
11.16.3 Replication topologies in a VTL environment 407
11.16.4 Visibility switch control 408
11.16.5 Single and multiple domain backup application environments 409
11.16.6 Adding replication to an existing production system 411
11.17 Many-to-one replication with VTL 413
11.17.1 Spoke 414
11.17.2 Hub 414

11.18 Many-to-many replication with VTL 416
11.19 ProtecTIER Replication with OST 418
11.19.1 Replication with OST 418
11.19.2 ProtecTIER Replication Manager tasks in OST 418
11.20 ProtecTIER Replication with FSI 419
11.20.1 Replication with FSI 419
11.21 IBM TS3000 System Console 420
11.22 Operating system 421

Chapter 12. Library management 423
12.1 Overview of library management 424
12.2 Management tools and technologies 424
12.2.1 Operator panel 425
12.2.2 Web user interface 426
12.2.3 Command-line interface 427
12.2.4 Tape System Library Manager 428
12.2.5 TapeAlert 429
12.2.6 Tape System Reporter 429
12.2.7 SNMP 432
12.2.8 SMI-S 433
12.2.9 IBM Tivoli Storage Productivity Center 433
12.2.10 IBM TotalStorage Tape Diagnostics Tool 434
12.2.11 IBM Ultrium Device Driver 435
12.2.12 Summary of management capabilities 437
12.3 Library-specific management capabilities 437
12.3.1 TS2900 tape autoloader 437
12.3.2 TS3100 tape library 437
12.3.3 TS3200 tape library 438
12.3.4 TS3310 tape library 438
12.3.5 TS3500 tape library 438
12.4 Preferred practices 439

Part 3. Appendixes 441

Appendix A. IPv6 support 443
Introduction to IPv6 444
IPv4 and IPv6 address formats 444
IPv6 supported list of IBM tape LIbrary products 446
TS3100 network configuration 447

Appendix B. IBM LTO Ultrium and 3592 media 449
Features available with the initial IBM hardware order 450
IBM stand-alone tape drives 450
IBM TS2900 tape autoloader 450
IBM TS3100 tape library 450
IBM TS3200 tape library 451
IBM TS3310 tape library 451
IBM TS3500 tape library 451
IBM TS4500 tape library 451
IBM 3589 LTO Ultrium tape cartridges 451
Cartridge compatibility 452
Model description and ordering media supplies 453

Bar code labels 455
IBM 3599 tape cartridges 456
Model description 456
Labeling service 461
Ordering bar code labels 463

Appendix C. IBM tape product names 465
TS series family names 466
TS1000 tape drives (LTO) 467
TS1100 tape drive (enterprise) 467
TS2000 Tape Enclosures (LTO) 468
TS2900 tape autoloader 468
TS3100 tape library 469
TS3200 tape library 469
TS3310 tape library 469
TS3400 tape library 470
TS3500 tape library 471
TS4500 tape library 471
TS7600 ProtecTIER 472

Appendix D. Data storage values 473

Related publications 475
IBM Redbooks publications 475
Other publications 475
Online resources 477
Help from IBM 478

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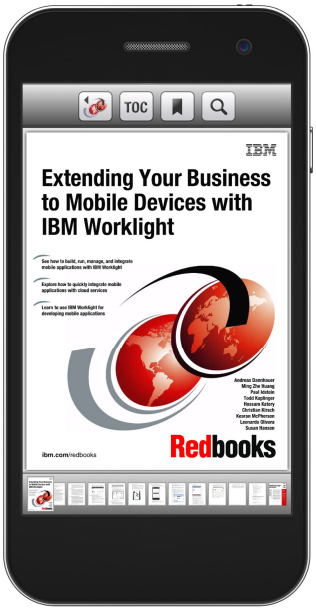
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Preface

This IBM® Redbooks® publication presents a general introduction to Linear Tape-Open (LTO) technology and the implementation of corresponding IBM products. The high-performance, high-capacity, and cost-effective IBM TS1150 tape drive is included. The book highlights the IBM TS4500 tape library, which is the next-generation storage solution that is designed to help midsize and large enterprises respond to storage challenges.

The IBM TS1150 tape drive gives organizations an easy way to deliver fast access to data, improve security, and provide long-term retention for less expense than disk solutions. TS1150 offers high-performance, flexible data storage with support for data encryption. This fifth-generation drive can help protect investments in tape automation by offering compatibility with existing automation.

This eleventh edition includes information about the latest enhancements to the IBM Ultrium family of tape drives and tape libraries. In particular, it includes details of the latest IBM LTO Ultrium 6 tape drive technology and its implementation in IBM tape libraries. It contains technical information about each IBM tape product for open systems and includes generalized sections about Small Computer System Interface (SCSI) and Fibre Channel connections and multipath architecture configurations. This edition also includes details about Tape System Library Manager (TSLM), which consolidates and simplifies large TS3500 tape library environments, including the IBM Shuttle Complex.

This book also covers tools and techniques for library management. It is intended for anyone who wants to understand more about IBM tape products and their implementation. It is suitable for IBM clients, IBM Business Partners, IBM specialist sales representatives, and technical specialists. If you do not have a background in computer tape storage products, you might need to read other sources of information. In the interest of being concise, topics that are generally understood are not covered in detail.

Authors

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- Markus Schaefer

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Summary of changes

This section describes the technical changes that were made in this edition of the book and in previous editions. This edition might also include minor corrections and editorial changes that are not identified.

For *IBM Tape Library Guide for Open Systems,* SG24-5946-10
as created or updated in February 2015

February 2015, Eleventh Edition

This revision reflects the addition, deletion, or modification of new and changed information.

New information

The book includes the following new information:

- IBM TS4500 tape library
- IBM TS1150 tape drive (3592 Model E08)
- IBM TS2260 tape drive update for optional USB 3.0 port
- TS1150 tape drive updates for IBM tape libraries
- IBM Linear Tape File System™ Enterprise Edition (LTFS EE)

Changed information

This book includes the following changed information:

- IBM TS1150 tape drive (Model 3592 EH8)
- IBM TS3500 tape library

June 2013, Tenth Edition

This revision reflects the addition, deletion, or modification of new and changed information.

New information

The book includes the following new information:

- IBM TS2260 LTO 6 tape drive
- IBM TS2360 LTO 6 tape drive
- LTO-6 tape drive updates for IBM tape libraries
- Tape Systems Library Manager (TSLM)
- IBM Linear Tape File System expanded installation and support information updated in a Redbooks publication: *Linear Tape File System: Installation and Configuration*, SG24-8090

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Changed information

This book includes the following changed information:

- IBM TS2260 tape drive
- IBM TS2360 tape drive
- IBM TS2900 tape autoloader
- IBM TS3100 tape library
- IBM TS3200 tape library
- IBM TS3310 tape library
- Removed IBM TS3400 tape library
- IBM TS3500 tape library
- IBM TS7600 ProtecTIER® Systems
- IBM Library Management

June 2012, Ninth Edition

This revision reflects the addition, deletion, or modification of new and changed information.

New information

The book includes the following new information:

- IBM TS1140 tape drive (3592 Model E07)
- IBM TS3500 tape library Shuttle Complex (Model SC1)
- High Performance Storage System (HPSS)
- IBM Linear Tape File System Single Drive Edition (LTFS SDE) expanded installation information
- IBM Linear Tape File System Library Edition (LTFS LE)
- LTO-5 tape drive updates for tape libraries

Changed information

This book includes the following changed information:

- IBM TS2250 tape drive
- IBM TS2350 tape drive
- IBM TS2900 tape autoloader
- IBM TS3100 tape library
- IBM TS3200 tape library
- IBM TS3310 tape library
- IBM TS3400 tape library
- IBM TS3500 tape library
- IBM TS7600 ProtecTIER Systems

June 2011, Eighth Edition

This revision reflects the addition, deletion, or modification of new and changed information.

New information

The book includes the following new information:

- ALMS required to support LTO-5 tape drives
- FC 1700 and FC 1701 required for LTO-5 support in Models L32/D32, L52/D52
- HA/HD mixed media configuration
- Linear Tape File System (LTFS)
- LTO-5 tape drives
- LTO-5 Bridge Boxes
- LTO-5 tape drives dual ported 8 Gbps Fibre Channel interface
- TS1050 (3588 F5A)

Changed information

This book includes the following changed information:

- TS2250
- TS2900
- TS3100
- TS3200
- TS3310
- TS3500

September 2008, Seventh Edition

This revision reflects the addition, deletion, or modification of new and changed information.

New information

The book includes the following new information:

- TS1130 tape drive
- TS2240 tape drive
- TS2900 tape autoloader
- TS3310 Advanced Reporting
- IPV6 Protocol
- ITDT Graphical Edition
- TS3500 High Density

Changed information

This book includes the following changed information:

- TS3100
- TS3200
- TS3310
- TS3400
- TS3500
- IBM Tivoli Productivity Center Version 3.3
- Library management

October 2007, Sixth Edition

This revision reflects the addition, deletion, or modification of the following new and changed information.

New information

The book includes the following new information:

- TS2230 tape drive
- TS2340 tape drive
- IBM Linear Tape-Open Ultrium 4 tape drive
- IBM TS3400 tape library
- Tape encryption

Changed information

The book includes the following changed information:

- IBM TS3310 tape library
- IBM TS3500 tape library

April 2007, Fifth Edition

This revision reflects the addition, deletion, or modification of the following new and changed information.

New information

The book includes the following new information:

- IBM TS3100 tape library
- IBM TS3200 tape library
- IBM TS3310 tape library
- Library management

Changed information

The book includes the following changed information:

- IBM TS1020 tape drive
- IBM TS1120 tape drive
- IBM TS3500 tape library

September 2005, Fourth Edition

This revision reflects the addition, deletion, or modification of the following new and changed information.

New information

The book includes the following new information:

- Write Once Read Many (WORM) media for Ultrium 3 drives
- Ultrium 3 drives and libraries
- Virtual I/O for IBM TotalStorage 3584 Tape Library

June 2004, Third Edition

This revision reflects the addition, deletion, or modification of the following new and changed information.

New information

The book includes the following new information:

- Description of WORM technology
- New models IBM TotalStorage 3581 2U Tape Autoloader L28 and F28
- New frames and features for the IBM TotalStorage 3584 Tape Library, including support for IBM TotalStorage 3592 Tape Drive with WORM media
- Advanced Library Management System (ALMS) for the IBM TotalStorage 3584 Tape Library

June 2003, Second Edition

This revision reflects the addition, deletion, or modification of new and changed information described below.

New information

- Ultrium 2 drives in existing LTO libraries
- New model, IBM TotalStorage Ultrium tape library 3582
- New functions (multi-path architecture, Control Path Failover) for LTO libraries

November 2000, First Edition

This revision reflects the addition of new and information described below.

New information

- Introduction to Linear tape-Open technology
- Introduction to the family of IBM LTO Ultrium products
- Configuration information for stand a lone environments and backup and recovery software
- General information for SCSI connections, multipath configurations and tape technology comparisons

Part 1

Tape basics of open systems

Part 1 covers information about tape technologies for open systems. It also includes information about the IBM tape drives that can be installed inside IBM tape libraries for open systems hosts.

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1

Tape technology introduction

Tape systems traditionally were associated with the mainframe computer market. They represented an essential element in mainframe systems architectures since the early 1950s as a cost-effective way to store large amounts of data. By contrast, the midrange and client/server computer market made limited use of tape technology until recently.

Over the past few years, growth in the demand for data storage and reliable backup and archiving solutions greatly increased the need to provide manageable and cost-effective tape library products. The value of using tape for backup purposes has only gradually become obvious and important in these environments.

This chapter reviews the history of tape technology, including the technologies, formats, and standards that you see for tape products in today's market. This chapter also includes information about several products from non-IBM vendors. For more information about these non-IBM vendors' products, see their respective websites.

This chapter includes the following sections:

- Tape products and technologies
- Tape virtualization for open systems
- Linear Tape File System (LTFS)

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1.1 Introduction

Magnetic tape was first used in 1930 for sound recording and later for video recording in 1951. In the following year, IBM invented the concept of using magnetic tape for computer data storage with the introduction of the IBM Model 726 - the world's first reel tape system. It had a storage density of 100 characters per inch and speeds up to 70 inches per second.

Since these early days, tape has continued to figure significantly in IT infrastructures for high-capacity storage backup. Its unique attributes can help users manage their storage requirements and contribute to the ever-present value of tape in the storage hierarchy.

Tape includes the following features:

- Removable: Store it securely to protect it from viruses, sabotage and other corruption.
- Scalable: Simply add more low-cost cartridges, not drives.
- Portable: Easily move it to another site to avoid destruction in the event the first site suffers threat or damage.
- Fast: Provides up to 400 MBps (with 2.5:1 compression ratio) for the IBM LTO (Linear Tape-Open) Generation 6 systems.
- Reliable: IBM servo technology, read after write verification and advanced error correction systems to help to make tape more reliable than disk.
- Green: Has low power consumption.

As new storage formats and devices are developed and refined, industry experts periodically forecast the demise of tape, pronouncing it slow and outmoded. However, tape continues to be the most cost-effective, flexible, and scalable medium for high-capacity storage backup.

Over the last 60 years, IBM has delivered many innovations in tape storage and that innovation continues today. This chapter provides a brief overview of the major changes that have taken place in tape technology over this time.

1.2 Timeline

Figure 1-1 shows a summary of significant events in the history of tapes in relation to data storage. These events are described in more detail in this chapter.

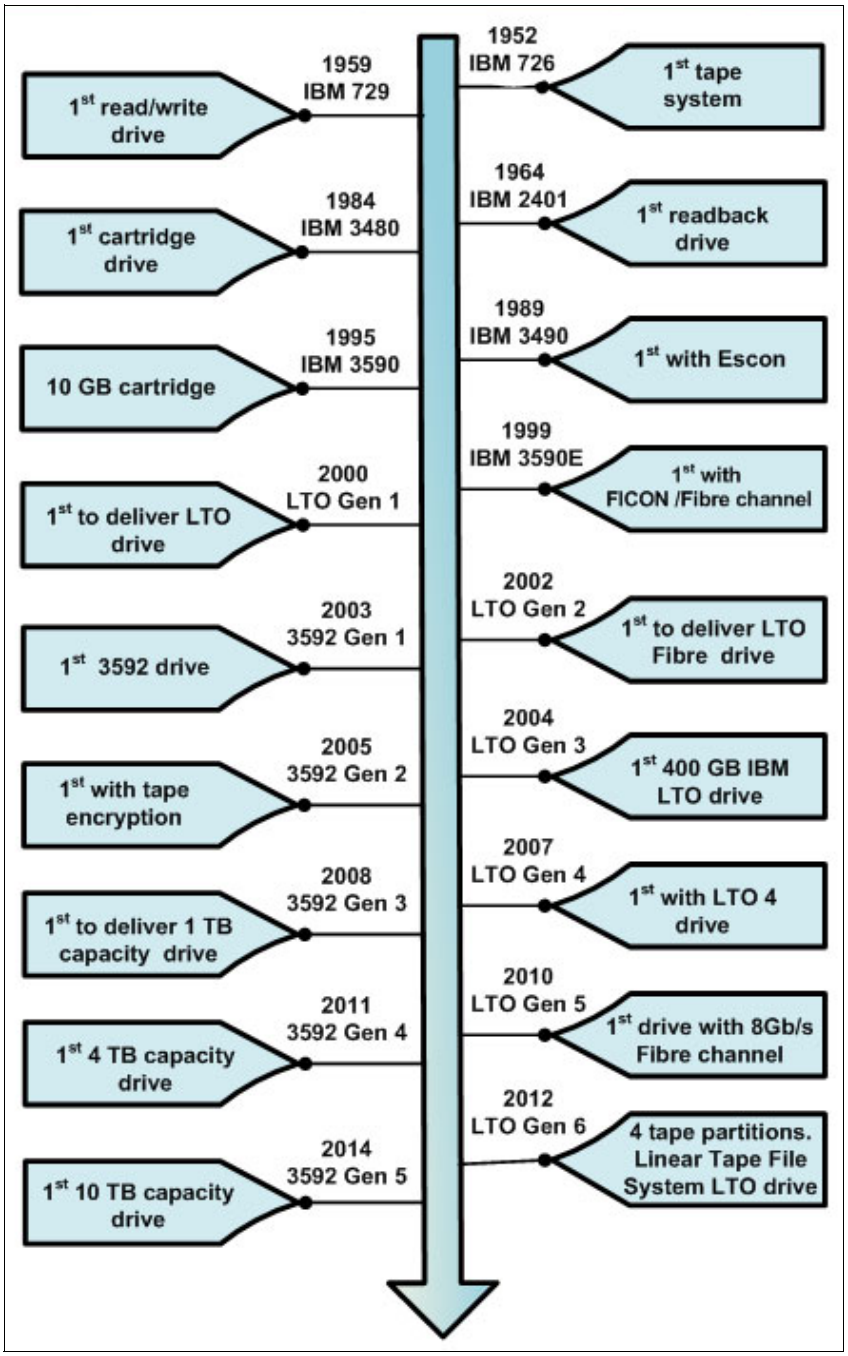


Figure 1-1 IBM tape timeline

1.3 Tape products and technologies

Table 1-1 shows a summary of important milestones in the evolution of tapes over the last 60 years. Each milestone is described in more detail in this chapter.

Table 1-1 Tape timeline

Year	Manufacturer	Model number	Density or capacity	Advancements
1952	IBM	726	100 characters/inch	First use of plastic tape on a reel
1958	IBM	729	200 characters/inch	First readback drive
1964	IBM	2400	800 bpi	9-track tape, EBCDIC and ASCII
1970	IBM	3400	6250 bpi	
1972	3M	QIC-11	20 MB	Quarter-inch cartridge with two reels
1974	IBM	3850		Tape cartridge with a single reel. First robotic tape library.
1984	IBM	3480	200 MB	Thin-film magnetoresistive (MR) head
1984	DEC	TK50	94 MB	Digital Linear Tape (DLT)
1986	IBM	3480	400 MB	Hardware data compression IRDC
1987	Exabyte	EXB-8200	2.4 GB	First helical scan tape drive
1989	HP	DDS1	2 GB	4 mm tape
1991	IBM	3490E	800 MB	
1992	IBM	3490E	2.4 GB	IRDC compression
1995	IBM	3590	10 GB	
1997	IBM	VTS		Virtual tape
1999	Exabyte	Mammoth-2	60 GB	
1999	HP	DDS4	20 GB	
2000	Quantum	Super DLT	110 GB	More precise head positioning
2000	IBM	LTO-1	100 GB	First LTO drive
2003	IBM	3592		Virtual backhitch
2003	IBM	LTO-2	200 GB	
2005	IBM	LTO-3	400 GB	

Year	Manufacturer	Model number	Density or capacity	Advancements
2006	IBM	3592		Encryption integrated into drive
2007	IBM	LTO-4	800 GB	
2008	IBM	TS1130	1 TB	GMR heads
2010	IBM	LTO-5	1.5 TB	2 tape partitions. Linear Tape File System (LTFS)
2011	IBM	TS1140	4 TB	
2012	IBM	LTO-6	2.5 TB	4 tape partitions
2014	IBM	TS1150	10 TB	

1.3.1 Recording technology

The first computer tape systems used linear recording technology. This technology provides excellent data integrity, rapid access to data records, and reasonable storage density. Until the mid-1980s, all computer tape systems employed this linear recording technology, which uses a stationary head writing data in a longitudinal way. (Figure 1-5 on page 9 shows an example of longitudinal technology.)

However, in the mid-1980s, helical tape technology (developed for video applications) became available for computer data storage. This technology uses heads that rotate on a drum and write data at an angle. Helical tape systems found natural applications in backing up magnetic disk systems where their cost advantages substantially outweighed their operational disadvantages. (Figure 1-6 on page 10 shows an example of helical scan technology.)

The first implementation of linear recording technology used magnetic tapes on open reels. Later, the tape was protected inside cartridges by using one or two reels. Linear technology drives write each data track on the entire length of the tape. Data is first written onto a track along the entire length of the tape. When the end is reached, the heads are repositioned to record a new track again along the entire length of the tape, which is now traveling in the opposite direction. This method continues back and forth until the tape is full. On linear drives, the tape is guided around a static head.

By contrast, on helical scan systems, the tape is wrapped around a rotating drum that contains read/write heads. Because of the more complicated path, mechanical stress is placed on the tape. When contrasted with linear tape systems, helical tape systems have higher density (and, therefore, lower media cost). However, they have lower data transfer rates (because of the smaller number of active read/write heads), less effective access to random data records, increased maintenance requirements, and reduced data integrity.

Linear and helical tape systems advanced substantially over the past decade. Linear systems improved significantly in storage density (and, therefore, cost). They also improved in operational convenience, with various removable cartridge systems, such as 3590, quarter-inch cartridge (QIC), digital linear tape (DLT), and now Linear Tape-Open (LTO), replacing reel-to-reel systems. Helical systems improved in the areas of transfer rate and data integrity with the implementation of both channel and error correction coding technologies.

Over the past few decades, one of the most significant advances in tape technology for computer applications was the maturation of serpentine linear recording systems. For the first time, linear recording systems can provide recording density that is comparable with that of helical systems. The first commercially successful serpentine linear tape system for professional applications was DLT. Another important improvement is the use of servo tracks, which was first introduced by IBM on the Magstar® 3590 tape. Servo tracks are recorded at the time of manufacture. These tracks enable the tape drive to position the read/write head accurately with respect to the media while the tape is in motion.

1.3.2 Tape reels

The first data backup device (and the ancestor of magnetic tape devices with a ½-inch-wide tape format) used magnetic tape reels, as shown in Figure 1-2. They were manufactured and sold in many different lengths and brands. The most common densities used were 1600 and 6250 bpi. The IBM 2400 was a 9-track 800 bpi tape drive. This was the first 9-track model from IBM that recorded EBCDIC (8-bit) or ASCII (7-bit) data. In the 1970s, the IBM 3400 was introduced and it supported up to 6250 bpi.

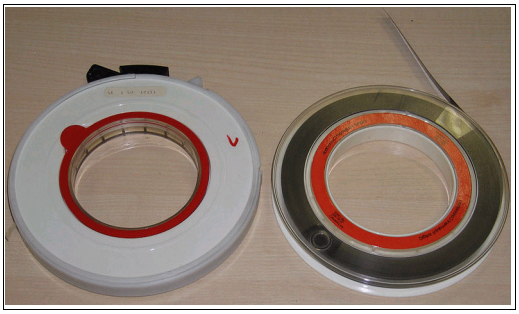


Figure 1-2 Tape reels, ½-inch

In the 1970s, the IBM 3400 was introduced and it supported up to 6250 bpi, as shown in Figure 1-3.



Figure 1-3 IBM 3420

1.3.3 Quarter-inch cartridge

The QIC tape device was first introduced in 1972 by the 3M company as a means to store data from telecommunications and data acquisition applications. As time passed, the comparatively inexpensive QIC tape device became an accepted data storage system, especially for stand-alone PCs.

A QIC tape device (shown in Figure 1-4) looks similar to an audio tape cassette with two reels inside, one with tape and the other for take-up.

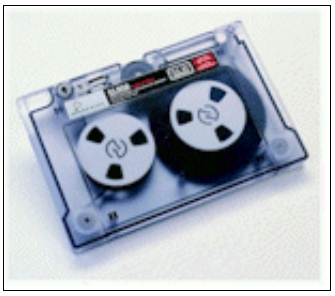


Figure 1-4 QIC tape

The QIC format employs a linear (or longitudinal) recording technique in which data is written to parallel tracks that run along the length of the tape. The number of tracks is the principle determinant of capacity.

The QIC uses a linear read/write head similar to the heads found in cassette recorders, as shown in Figure 1-5. The head contains a single write head that is flanked on either side by a read head, so that the tape drive can verify data just written when the tape is running in either direction.

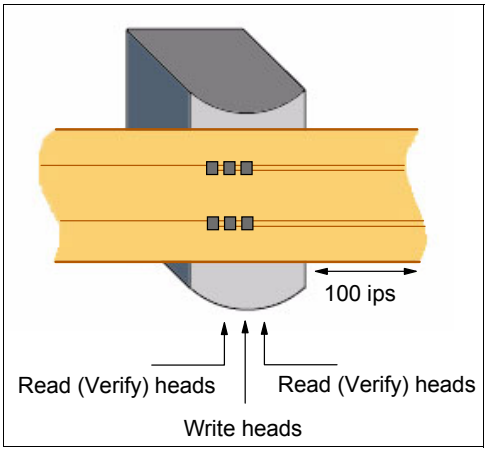


Figure 1-5 QIC head diagram

Tandberg Data manufactures QIC drives with its Scalable Linear Recording (SLR) technology. Their most recent drive, the SLR140, provides 70 GB (native) and 140 GB (with a 2:1 compression ratio) capacity on a single data cartridge. The maximum data transfer rates are 6 MBps uncompressed and 12 MBps (with a 2:1 compression ratio).

1.3.4 Digital Data Standard

The Digital Audio Tape (DAT) standard was created in 1987. As its name implies, it was originally conceived as a CD-quality audio format that offered three hours of digital sound on a single tape. The Digital Data Standard (DDS) is based on DAT and uses a similar technology. The cartridge design is common to both, but different tape formulations have been developed. In 1988, Sony and Hewlett-Packard (HP) defined the DDS standard, which transformed the format into one that can be used for digital data storage.

DAT technology is a 4 mm tape that uses helical scan recording technology (as shown in Figure 1-6). Over the years, the DAT capacity has grown from DDS-1 at 1.3 GB to DAT-320 at 160 GB (native) and 320 GB (with a 2:1 compression ratio). This technology is the same type of recording that is used in videocassette recorders (VCRs) and is inherently slower than the linear type. The tape in a helical scan system is pulled from a two-reel cartridge and wrapped around a cylindrical drum that contains two read heads and two write heads, arranged alternately. The read heads verify the data that is written by the write heads. The cylinder head is tilted slightly in relation to the tape and spins at 2000 revolutions per minute (RPM). The tape moves in the opposite direction to the cylindrical spin, at less than one inch per second. However, because it is recording more than one line at a time, it has an effective speed of 150 inches per second.

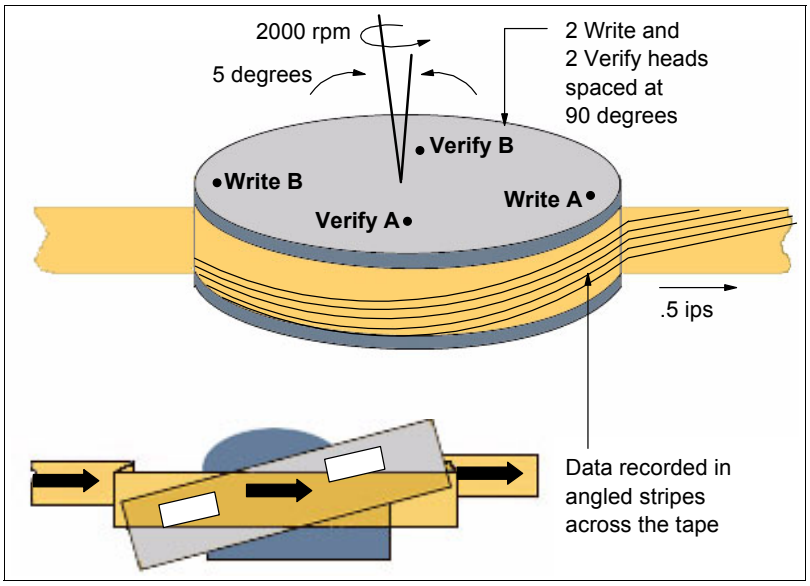


Figure 1-6 Helical-scan recording diagram

A directory of files is stored in a partition at the front of the tape. Similar to linear recording, the performance can be greatly improved if more read/write heads are added. However, this change is difficult with helical scan devices because of the design of the rotating head. The fact that the heads only can be added in pairs makes it challenging to fit the wiring inside a single cylinder, which limits the potential performance of helical scan devices. Because of the wide-wrap angle of the tape and the consequent degree of physical contact, the head and the media are prone to wear and tear.

1.3.5 The 8 mm format

Designed for the video industry, 8 mm tape technology was created to transfer high-quality color images to tape for storage and retrieval and was adopted by the computer industry. Similar to DAT, but with greater capacities, 8 mm drives also are based on the helical scan technology. One of the earliest was the Exabyte EXB-8200. A drawback to the helical scan system is the complicated tape path. Because the tape must be pulled from a cartridge and wrapped tightly around the spinning read/write cylinder (as shown in Figure 1-7), a great deal of stress is placed on the tape.

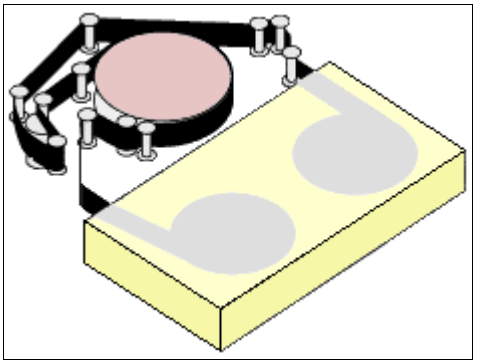


Figure 1-7 An 8 mm tape path

Two major protocols use different compression algorithms and drive technologies, but the basic function is the same. Exabyte Corporation sponsors standard 8 mm and VXA formats, while Seagate and Sony represent the 8 mm technology known as Advanced Intelligent Tape (AIT).

Mammoth tape format

The Mammoth tape format is a Small Computer System Interface (SCSI) based 8 mm tape technology that is designed for open systems applications. It is a proprietary implementation of the 8 mm original format that has been available since 1987 and uses Advanced Metal Evaporative (AME) media. This media has a coating over the recording surface that seals and protects the recording surface.

The Exabyte Mammoth drives have a 5¼-inch form factor. The first generation provided 20 GB (native) and 40 GB (with a 2:1 compression ratio) capacity on a single 8 mm data cartridge. The maximum data transfer rates were 3 MBps uncompressed and 6 MBps (with a 2:1 compression ratio).

With the Mammoth-2 technology, the capacity and data rate increased to 60 GB (150 GB with a 2.5:1 compression ratio) and 12 MBps uncompressed 30 MBps with a 2.5:1 compression ratio). Mammoth-2 drives are read compatible with the previous models.

VXA tape format

The VXA tape format is 8 mm tape technology that is designed for open systems applications. It is a proprietary implementation of an 8 mm packet format that is available since 2001 and uses AME media.

The Exabyte VXA drives have a 5¼-inch form factor. The first generation provided 32 GB (native) and 64 GB (with a 2:1 compression ratio) capacity on a single 8 mm data cartridge. The maximum data transfer rates were 3 MBps uncompressed and 6 MBps (with a 2:1 compression ratio).

With the VXA-2 technology, the capacity and data rate increased to 80 GB (160 GB with a 2:1 compression ratio) and 6 MBps uncompressed (12 MBps with a 2:1 compression ratio). VXA-2 drives are read compatible with the previous model.

With the VXA-3 technology, the capacity and data rate increased to 160 GB (320 GB with a 2:1 compression ratio) and 12 MBps uncompressed (24 MBps with a 2:1 compression ratio). VXA-3 drives are read compatible with the previous model.

Advanced Intelligent Tape format

The Advanced Intelligent Tape (AIT) format was developed by Sony. Available in a 3½-inch form factor, Sony AIT-1 drives and media provide 25 GB (native) and 50 GB (with a 2:1 compression ratio) capacity on a single 8 mm data cartridge. The maximum data transfer rate is 3 MBps native.

The AIT-5 format from Sony has the capacity and performance of 400 GB (1040 GB with a 2.5:1 compression ratio) and 24 MBps data transfer rate.

AIT drives feature an Auto Tracking Following (ATF) system, which provides a closed-loop, self-adjusting path for tape tracking. This servo tracking system adjusts for tape flutter, so that data tracks can be written much closer together for high-density recording. AIT uses the Adaptive Lossless Data Compression (ALDC) technology compression algorithm.

Digital Linear Tape

Digital Linear Tape (DLT) drives became available in 1985 when Digital Equipment Corporation needed a backup system for their MicroVAX systems. This system uses a square cartridge that contains tape media but no take-up reel. The take-up reel was built into the drive itself. This design eliminated the space that was typically associated with cassette and cartridge drives, such as QIC or 8 mm. The drive had to be made larger than most drives to accommodate the internal take-up reel. The drive fit into a Full-High, 5¼-inch drive bay. Called the TK50, the tape drive was capable of storing 94 MB per cartridge.

By using a ferrite read/write head, the TK50 recorded data in linear blocks along 22 tracks. Its read/write head contained two sets of read/write elements. One set was used when reading and writing forward, and the other set was used when reading and writing backward.

In 1987, Digital Equipment Corporation released the TK70. This tape drive offered 294 MB of storage on the same square tape cartridge, a threefold improvement over the TK50. Digital accomplished this capacity by increasing the number of tracks to 48 and by increasing density on the same ½-inch tape.

In 1989, Digital Equipment Corporation introduced the first true DLT system. The TF85 (later called the DLT 260) incorporated a new feature that enabled the system to pack 2.6 GB onto a 1200-foot tape (CompacTape III, later known as DLTtape III).

The DLT Tape Head Guide Assembly was incorporated for the first time in the TF85 drive. Six precision rollers improved tape life. The six-roller head guide assembly gave the TF85 a much shorter tape path than helical scan systems, as shown in Figure 1-8.

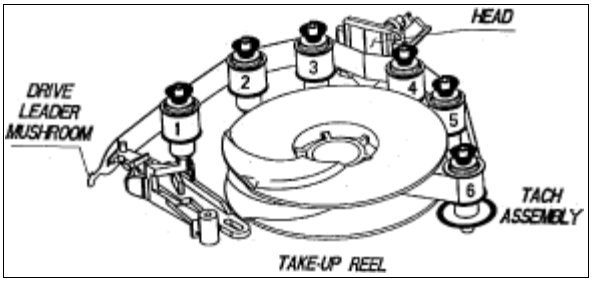


Figure 1-8 DLT tape path mechanism

The read/write head was equipped with another write element so that the elements were arranged in a write/read/write pattern. With this pattern, the TF85 reads after writing on two channels and in forward and reverse directions, as shown in Figure 1-9.

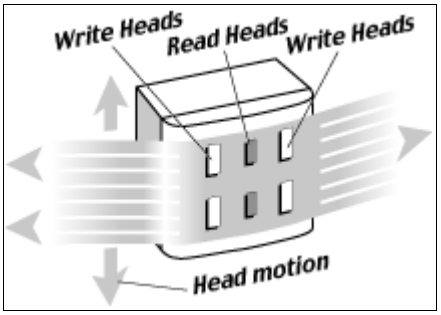


Figure 1-9 DLT 2000 recording head design

Two years later, Digital Equipment Corporation introduced the TZ87, later known as the DLT 2000 tape drive. This system offered 10 GB of native capacity on a single CompacTape III cartridge (Figure 1-10), later known as DLTtape III. It supported 2 MB of read/write data cache memory and offered a data transfer rate of 1.25 MBps. This cartridge was the first generation of DLT.

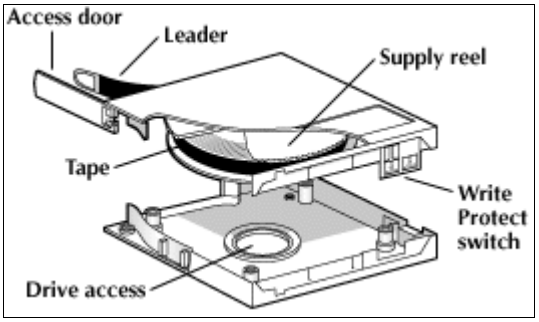


Figure 1-10 DLT cartridge

In 1994, Quantum acquired the Storage division of Digital Equipment Corporation. In late 1994, Quantum released the DLT 4000. By increasing real density (bits per inch) from 62,500 to 82,000 and tape length by 600 feet (DLTtape IV), the capacity of the DLT 4000 grew up to 20 GB (40 GB compressed) on a single ½-inch DLTtape IV cartridge. The new DLT tape system provided a data transfer of 1.5 MBps (3 MBps compressed) and was fully read/write compatible with previous generations of DLT tape drives.

DLT 2000 and DLT 4000 drives write data on two channels simultaneously in linear tracks that run the length of the tape, as shown in Figure 1-11.

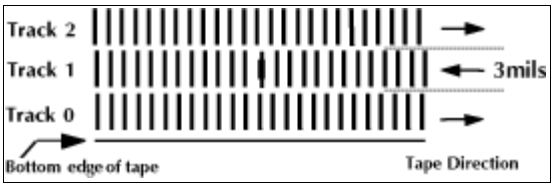


Figure 1-11 DLT 2000/4000 linear recording format

The DLT 7000 became available in 1996. This drive offered a total storage capacity of 35 GB native and 70 GB compressed on the 1800 foot DLTtape IV cartridge. The DLT 7000 incorporated a 4-channel head that gives the drive a transfer rate of 5 MBps of data in native mode, as shown in Figure 1-12.

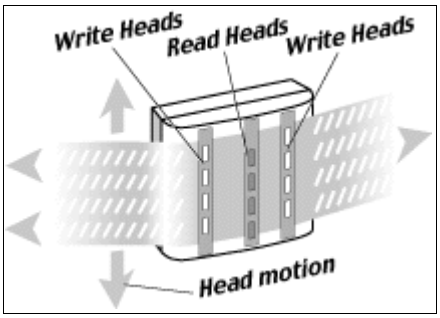


Figure 1-12 DLT 7000/8000 tape head

The latest DLT product from Quantum is the DLT 8000 drive. This tape drive features a native transfer rate of up to 6 MBps, with a native capacity of 40 GB. The DLT 7000/8000 drives incorporate the Symmetric Phase Recording technology that writes data in an angled pattern, as shown in Figure 1-13.

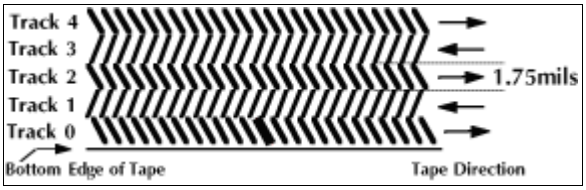


Figure 1-13 Symmetric Phase Recording technology

1.3.6 SuperDLT

SuperDLT (SDLT) is a format specification that was developed by Quantum Corporation as an evolution of the DLT standard. It uses Laser Guided Magnetic Recording (LGMR) technology. This technology includes the Pivoting Optical Servo (POS). This optically-assisted servo system is implemented on the unused reverse side of the media and uses a laser to read the servo guide. SDLT uses 100% of the media for data recording. SDLT uses Advanced Metal Powder (AMP) media, which contains embedded information for the Pivoting Optical Servo system.

The recording mechanism is made of Magneto-Resistive Cluster (MRC) heads, which are a cluster of small magneto-resistive tape heads.

The first SDLT drive (the SDLT 220) was introduced in late 2000. It provides a capacity of 110 GB (native) and 220 GB (with a 2:1 compression ratio). The native data transfer rate is

11 MBps. This first drive was not backward-read compatible with earlier models. In 2001, Quantum released a version of the SDLT 220 drive that was backward-read compatible with the DLTtape IV cartridge.

The second SDLT 320 drive from Quantum became available in 2002. It increased the native capacity to 160 GB (320 GB with a 2:1 compression ratio) and the native transfer rate to 16 MBps (32 MBps with a 2:1 compression ratio). The SDLT 320 is backward read compatible with DLTtape IV cartridges and uses Super DLTtape I media.

The SDLT 600 is the third generation of the SDLT product range from Quantum. It provides a capacity of 300 GB (native) and 600 GB (with a 2:1 compression ratio) and the native transfer rate increased to 36 MBps (72 MBps with a 2:1 compression ratio). The SDLT600 comes with an LVD 160 Small Computer System Interface (SCSI) or with a 2 GB Fibre Channel (FC) interface. The SDLT 600 is compatible with earlier versions with the SDLT 320 and the DLT VS 160.

The DLT-S4 is the fourth generation of the SDLT product range from Quantum. It provides a capacity of 800 GB (native) and 1.6 TB (with a 2:1 compression ratio) and the native transfer rate increased to 324 MBps (400 MBps with a 2:1 compression ratio). The DLT-S4 comes with an LVD 320 Small Computer System Interface (SCSI) or with a 4 GB Fibre Channel (FC) interface. The DLT-S4 can read all Super DLTtape 2 cartridges written by SDLT 600 drives, and Super DLTtape 1 cartridges written by SDLT 320 drives

The media format has the following capacity:

- DLT-4 (read/write) 800 GB native capacity
- Super DLTtape II (read only) 300 GB native capacity
- Super DLTtape I (read only) 160 GB native capacity

1.3.7 IBM 3850

Beginning in the late-1960s, IBM engineers in Boulder, Colorado, began development of a low-cost mass storage system that was based on magnetic tape in cartridges. By 1970, the proposed device was code named “Comanche” and was described as an online tape library to provide computer-controlled access to stored information. Numerous marketing studies and design changes were made during the early 1970s, and finally Comanche was announced as the IBM 3850 Mass Storage System (MSS) in October 1974.

The components of the 3850 were new data cartridges. The data cartridges were circular cylinders, two inches in diameter and four inches long, each holding a spool holding 770 inches of tape. Cartridges were stored in a two-dimensional array of bins, which were hexagonal, rather than square, to save space and, for the first time, were automatically accessed via a robot (accessor), shown in Figure 1-14

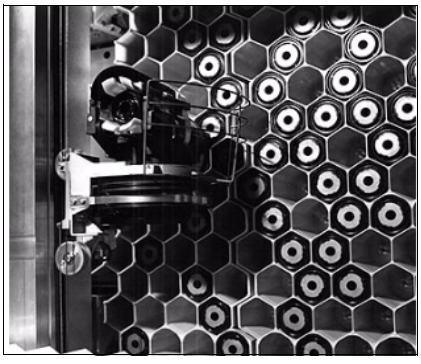


Figure 1-14 IBM 3850

1.3.8 IBM 3480

The second generation of IBM magnetic media and the first one to use an enclosed cartridge containing ½-inch tape, the IBM 3480 Magnetic Tape Subsystem was announced on 22 March 1984, shown in Figure 1-15. The tape was stored in a now-familiar cartridge, which was smaller, more robust, and easier to handle than tape reels. The cartridge capacity was 200 MB, and the channel data rate was 3 MBps, writing 18 tracks in one direction.



Figure 1-15 IBM 3480

1.3.9 IBM 3490

The IBM 3490 replaced the IBM 3480 tape technology and used the same tape cartridge media. With a tape capacity of 800 MB uncompacted (2.4 GB compressed assuming 3:1 compression ratio) and a channel data rate of 3 MBps, the IBM 3490E increased the capacity of the 3480 four-fold. It used a double-length tape and wrote data in both directions: 18 tracks to the end of tape and 18 tracks back to the start of the tape.

During this second generation, automatic cartridge loaders and automated tape libraries, such as the IBM 3495 and 3494 libraries, were introduced to reduce or eliminate the need for tape operators. Software management applications, such as CA-1, TLMS, and the DFSMS Removable Media Manager (DFSMSrmm), were implemented to manage the tape volumes automatically.

The IBM 3490 and compatible drives were probably the first family of tape products that was mostly used with automatic tape libraries rather than being installed as stand-alone drives operated manually.

The Improved Data Recording Capability (IDRC), which compacts the data, reduced the number of tape volumes that were used.

Magnetic disks were widely used for online data. Therefore, these second-generation tape systems became primarily a medium for backup and were introduced as an archive medium. The process of archiving was also automated with products, such as Hierarchical Storage Manager (HSM) and DFSMShsm (a component of DFSMS/MVS), by using tape as the lowest level in a storage hierarchy. Tape was still used as an interchange medium, but networks were also used for that purpose.

1.3.10 IBM 3590

The IBM TotalStorage Drive 3590 was called the IBM Magstar 3590. The IBM Magstar tape technology was first introduced in July 1995. The original cartridge maintained the external form factor of the IBM 3490 (as shown in Figure 1-16), had a capacity of 10 GB uncompacted (30 GB compressed), and a data rate of 9 MBps. Later drive models and newer media increased these figures. The data format was incompatible with the IBM 3490.

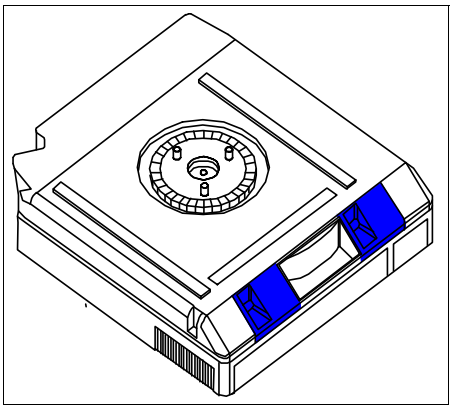


Figure 1-16 TotalStorage 3590 tape cartridge

The IBM 3590 drive (as shown in Figure 1-17) incorporated longitudinal technology, Serpentine Interleaved Longitudinal Recording.

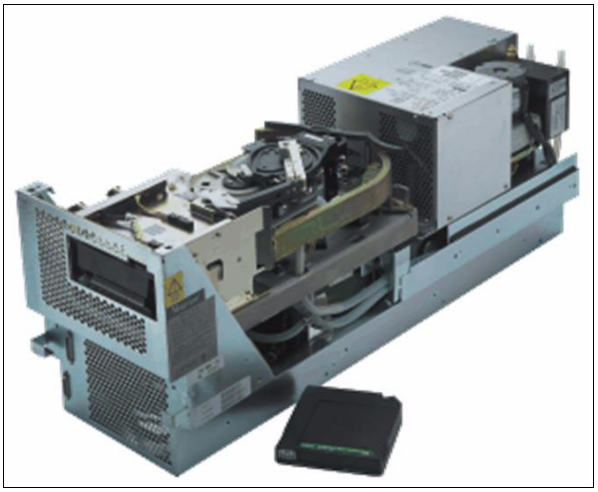


Figure 1-17 TotalStorage 3590 tape drive

Data was written in each direction in turn. To increase capacity further, the concept of *head indexing* was introduced, which wrote multiple sets of tracks in parallel. The entire set of heads was slightly shifted after one pass, and all subsequent passes (for a total of eight) were used to write data tracks next to the existing ones. This method meant a significant improvement in the tape capacity and transfer rates without changing the tape speed (2 mps) and media length (600 m). The IBM 3590 drive used a buffer and compressed the data before it wrote the data to tape. In addition, the drive completed a stop-start cycle in approximately 100 ms. The performance was improved for both start-stop and streaming applications.

With the IBM TotalStorage 3590 Model H, the capacity and data rate increased to 60 GB (180 GB assuming 3:1 compression ratio). With the Extended Length Cartridges, the capacity and data rate increased to 14 MBps native. Both drives were made available in 2002 and maintain compatibility with earlier version for reading with the base models.

This design incorporated innovations such as servo tracks on the tape to guide the read/write heads along the data tracks and the implementation of an improved error correcting code (ECC). A portion of the tape within each cartridge was reserved for statistical information. This portion was continually updated after each read or write. It provided statistics that you can use to obtain drive and media information and identify problems with a particular tape or drive as early as possible.

Technology

The IBM 3590 provided high capacity, performance, reliability, and a wide range of host connectivity. This technology used a fourth-generation magneto resistive (MR) head, a 16 MB buffer, predictive failure analysis, and state-of-the-art electronic packaging.

While reading or writing 16 tracks at a time, the IBM 3590 models used serpentine, interleaved, longitudinal recording technology for a total of four, eight, or twelve round trips from the physical beginning to the physical end of the tape and back again. The tape read/write head indexes, or moved vertically, when it completed each round trip so that the recorded tracks are interleaved across the width of the tape.

Figure 1-18 shows the recording element of the IBM TotalStorage Enterprise 3590 tape drives. It also shows how the read/write heads moved over the width of the tape medium.

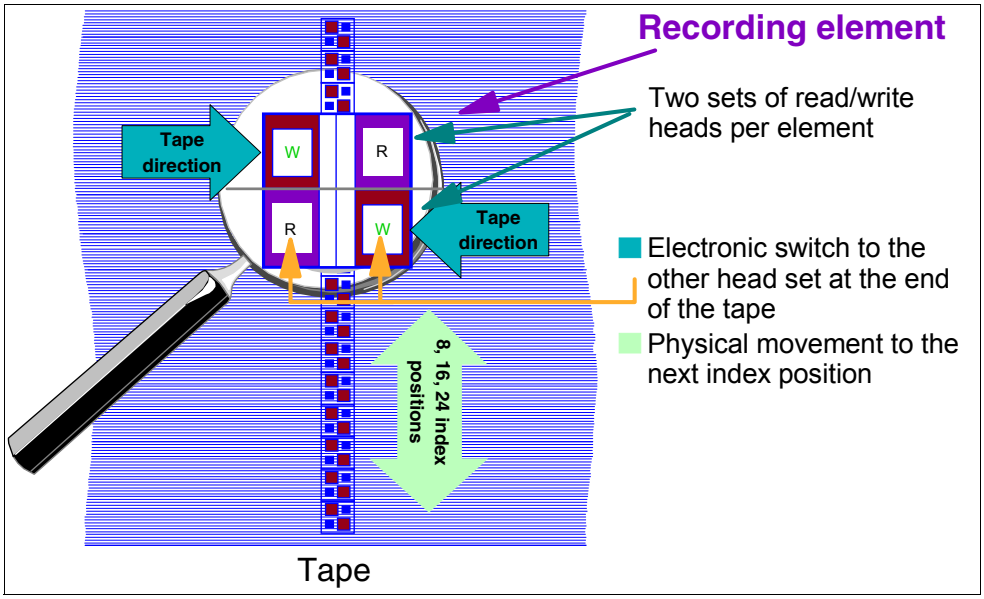


Figure 1-18 IBM 3590 recording

The 3590 tape drives used a metal particle medium in the tape cartridge that stores 10, 20, 30, 40, or 60 GB of uncompacted data, depending on the cartridge type and the drive model. The integrated control unit used a compaction algorithm that increases the storage capacity of these cartridges. Assuming a compression ratio of three to one (3:1), the cartridge capacity increased to 60 GB on E models and to 90 GB on H models.

The 3590E and 3590H models have a 14 MBps device data rate, and the 3590B models have a 9 MBps device data rate. With data compression, the 3590 tape drive can more effectively use the full capability of the Ultra-SCSI data rate, the IBM Enterprise Systems Connection (ESCON) data rate, or the IBM Fibre Connection (FICON®) data rate. The Ultra Wide SCSI data rate is up to 40 MB per second and the Fibre Channel data rate is up to 100 MB per second.

Metal particle media

A chromium dioxide medium was used in the IBM 3480 and 3490 cartridges. The IBM 3590 High Performance Tape Cartridge used a metal particle medium, which has a significantly increased coercivity. Therefore, it permits a much higher data recording density in comparison with chromium dioxide media as the linear density is proportional to the coercivity of the medium. The linear density of the IBM 3590 tape is approximately three times that of the IBM 3480 and 3490. The track density is also improved approximately four-fold. Advances in the metal particle coatings and media binders afford reliability and magnetic stability equal or superior to chrome media.

1.3.11 LTO Ultrium tape

The LTO standard was released as a joint initiative of IBM, Hewlett-Packard, and Seagate Technology. As result of this initiative, two LTO formats (Ultrium and Accelis) were defined. However, for performance reasons, there was no demand for the Accelis format of the LTO tape, and drive nor media were commercially produced.

The consortium now consists of IBM, Hewlett-Packard, and Quantum, which are known as the *technology provider companies*. The technology specifications are available at this LTO website:

`http://www.lto-technology.com`

The LTO Ultrium 6 technology is the current generation of LTO Ultrium tape. It provides 2.5 terabytes (TB) of native physical capacity (6.25 TB compressed) per cartridge and native data transfer rate of up to 160 MBps (400 MBps by assuming a 2.5:1 compression ratio). The previous format LTO Ultrium generations provided the following native capacities by using the transfer rates shown:

- LTO Ultrium generation 5 provided a native capacity of 1.5 TB with a native transfer rate up to 140 MBps.
- LTO Ultrium generation 4 provided a native capacity of 800 GB with a native transfer rate up to 120 MBps.
- LTO Ultrium generation 3 provided a native capacity of 400 GB with a native transfer rate up to 80 MBps.
- LTO Ultrium generation 2 provided a native capacity of 200 GB with a native transfer rate up to 40 MBps.
- LTO Ultrium generation 1 provided a native capacity of 100 GB with a native transfer rate of up to 20 MBps.

Each LTO Ultrium generation has doubled the compressed media storage capacity and increased the data transfer rate. Further, each LTO Ultrium drive generation is compatible with earlier versions for read and write capability with the prior media generation. Each LTO Ultrium drive generation is also compatible with earlier versions for read capability with the two prior media generations.

For more information about the LTO Ultrium tape format specification, see 2.1.2, “LTO standards” on page 45. For more information about the IBM LTO Ultrium tape drive, see 2.1.5, “IBM LTO Ultrium common subassembly drive” on page 55.

LTO WORM cartridges

The IBM Ultrium Write Once Read Many (WORM) cartridges (Machine Type 3589) were designed for applications, such as archiving and data retention, and for applications that require an audit trail. The IBM Ultrium WORM cartridges work with the IBM LTO Ultrium tape drive to prevent the alteration or deletion of user data. In addition, IBM has taken the following steps to reduce the possibility of tampering with the information:

- The bottom of the cartridge is molded in a different color than rewritable cartridges.
- The special cartridge memory helps protect the WORM nature of the media.
- A unique format is factory-written on each WORM cartridge.

The IBM LTO Ultrium 6 WORM format, based on LTO specifications, provides a tape cartridge capacity of up to 2.5 TB native physical capacity (6.25 TB with a 2.5:1 compression ratio). The 2.5 TB WORM cartridge can be used only in the IBM Ultrium 6 tape drive. Additionally, the IBM LTO Ultrium 6 tape drive can process the previous LTO Ultrium 5 1.5 TB WORM format for read and write data and can read data from the LTO Ultrium 4 800 GB WORM format.

1.3.12 IBM TS1100 tape drive family

The IBM TS1100 tape drive family offers a design that is focused on high capacity, performance, and high reliability for storing mission-critical data. Introduced in October 2003, the 3592-J1A tape drive had 300 GB of native capacity in a ½-inch format tape cartridge. It was also a foundation for future generations of this new tape drive family based on the concept of media reuse. This design helps protect the client's investment in tape cartridges.

In October 2005, the second generation of the 3592 drive, the IBM TS1120 tape drive Model E05, was introduced. The IBM 3592-E05 has the same physical measurements as the 3592-J1A tape drive, but the capacity increased 1.6 times from 300 GB to 500 GB native capacity on one cartridge. It has a 4 GB Fibre Channel attachment and a native data rate of up to 100 MBps.

The capacity characteristics of the third generation of 3592 tape drives increased again. The TS1130 Model E06 tape drive was the third generation of the 3592 family achieving the unprecedented capacity of 1 TB of uncompressed data.

The fourth generation of 3592, the IBM TS1140 model E07, again took tape capacity to a new level. The TS1140 can store 1.6 TB of uncompressed data on the JB cartridge type and 4 TB of uncompressed data on the advanced JC cartridge type.

With the fifth generation of 3592, the IBM TS1150 model E08, IBM has taken tape capacity to a new level yet again. The TS1150 can store 7 TB of uncompressed data on the existing JC cartridge types, and unprecedented capacity of 10 TB of uncompressed data on the new advanced JD cartridge types with improved levels of performance.

Figure 1-19 shows the IBM TS1150 tape drive, 3592 Model E08.



Figure 1-19 IBM TS1150 tape drive 3592 Model E08

For more information about the IBM 3592 J1A tape drive, the TS1120 tape drive, the TS1130 tape drive, TS1140 tape drive, and the TS1150 tape drive, see Chapter 3, “IBM TS1100 tape drives” on page 105.

The TS1150 tape drive maintains the same features and technology enhancements that were introduced with the TS1120 and extended by the TS1130 and TS1140. The TS1150 also offers several enhancements over the predecessor models. These are explained next.

TS1100 family key features

The TS1150 has the following key features, including those below which were introduced with the 3590 J1A, TS1120, TS1130, and TS1140:

- Digital speed matching
- Channel calibration
- High-resolution tape directory
- Recursive accumulating backhitchless flush or non-volatile caching
- Backhitchless backspace
- Streaming Lossless Data Compression (SLDC) algorithm
- Capacity scaling
- Single field replaceable unit (FRU)
- Error detection and reporting
- Statistical Analysis Recording System (SARS) algorithm with extended mount count
- Revised encryption support
- Dual-stage 32-head actuator
- Offboard data string searching
- Enhanced logic to report logical end of tape
- Added partitioning support
- End-to-end logical block protection support
- Data safe mode
- Enhanced Ethernet support
- Enhanced Barium Ferrite (BaFe) particle media types

- 8 Gbps Fibre Channel (FC) dual port interface
- Enhanced read-ahead buffer management
- High access performance for locate/search
- SkipSync and FastSync write performance accelerators
- 32-channel enhanced ECC recording format

Performance improvement

The performance on the TS1150 is increased by the following improvements:

- Improved data rate and capacity
- Improved latency by reducing access time to data
- Improved data compression
- Beginning of Partition (BOP) caching
- Humidity sensor support
- Increased Cartridge Memory size and related functions
- Improved High Resolution Tape Directory (HRTD)
- Larger main data buffer
- Extended copy support

Higher data rates and capacity

The following format data rates are available for the TS1150:

- Using the E08 format, data rates go up to 360 MBps maximum native and to 700 MBps maximum compressed.
- Using the E07 format, data rates go up to 250 MBps maximum native and to 650 MBps maximum compressed.

Table 1-2 summarizes the capacity and performance characteristics for uncompressed data.

Table 1-2 Native capacity and performance summary

Media Type	E08 format capacity data rate (minimum–maximum)	E07 format capacity data rate (minimum–maximum)
JC, JY	7 TB 80 MBps - 300 MBps	4 TB 50 MBps - 250 MBps
JD, JZ	10 TB 90 MBps - 360 MBps	N/A
JK	900 GB 60 MBps - 250 MBps	500 GB 50 MBps - 250 MBps
JL	2 TB 60 MBps - 360 MBps	N/A

1.3.13 Libraries

System administrators are clamoring for technologies that help them to efficiently and economically manage the explosive growth in stored data. As the amount of data increases, the backup process takes longer and longer. The solution to this problem is to use a device that integrates the tape drive with a level of automation. The challenge is to choose the right solution in terms of size and automation level.

System administrators industry-wide recognized the need to automate the backup-and-restore process to the extent that it requires little or no human intervention. This method has become known as *lights-out backup*. This process can be done off-shift or concurrently with other applications during normal operations. Multi-drive tape libraries are the only available technology to offer reliability and low cost to make lights-out backup practical.

The hardware options for automation are autoloaders and a range of multi-drive automated tape libraries.

Autoloaders

Autoloaders have one tape drive. Clients typically use autoloaders to access a small number of tapes once a day. Most autoloaders are designed for purely sequential operations. These units place little emphasis on performance.

Automated tape libraries

Automated tape libraries have one or more tape drives, but clients typically use them with at least two tape drives. All tape cartridges are accessible to all drives, thereby making concurrent reading and writing operations possible.

You can increase throughput by adding more drives and HBA's. With automation eliminating the manual intervention to load tapes, file-restore response times are substantially improved. Tape libraries are mandatory for lights-out operations and other higher performance tape storage applications. Tape libraries also offer the security of knowing that other drives are available if one fails.

Multi-drive automated tape libraries and ultra-scalable tape libraries, combined with storage management software, including concurrent backup, archive, and hierarchical storage management (HSM), offer the most robust solution for managing and protecting huge amounts of corporate data. Automated tape libraries allow random access to large numbers of tape cartridges and the concurrent use of two or more drives, rather than manually loading one tape after another or by using a single-drive sequential autoloader.

Enterprise tape libraries

Enterprise tape libraries are automated tape libraries that provide enhanced levels of automation, scalability, reliability, availability, and serviceability. They typically have the capacity to house dozens of drives and hundreds of tapes. Equipped with high-performance robotic mechanisms, bar code scanners, and support for cartridge I/O ports, these libraries often offer redundant components and a high degree of flexibility through a modular design. Certain models add support for multiple SCSI, Fibre Channel-Arbitrated Loop (FC-AL), Fibre Channel Protocol (FCP), and ESCON or FICON connections to allow connection to more than one host platform.

The top-of-the-line of the enterprise tape library products, such as the IBM TS3500 tape library and the IBM TS4500 tape library, can be shared between two or more heterogeneous host systems. All of the hosts have access to the control functions of the tape library robotics. The library is shared in a physical way, with each system operating as though it really owns the entire library.

TS3500 tape library Shuttle Complex

The TS3500 tape library Shuttle Complex enables extreme scalability of over 300,000 LTO cartridges (or over 2 EiB of uncompressed TS1150 data) in a single library image by supporting transport of cartridges from one TS3500 tape library string to another TS3500 tape library string. Application software that supports this capability can move tape cartridges

directly from its home logical library to the destination logical library. Shuttle connections span high-density TS3500 S24 or S54 frames from different TS3500 tape library strings. The TS3500 tape library Shuttle Complex supports new and existing TS3500 tape library installations and is particularly well-suited for High Performance Storage System (HPSS) environments. The recent introduction of IBM Tape System Library Manager (TSLM) now gives users an alternative means of managing the Shuttle Complex.

Important: At the time of writing, HPSS and TSLM are the only library management solutions that support the TS3500 tape library Shuttle Complex.

To meet the needs of large data center archives that must store increasing amounts of data, the TS3500 tape library offers shuttle technology that enables flexible library growth on a z-axis. This growth flexibility, enabled by shuttle connections between HD libraries, allows a higher maximum capacity for a single library image of multiple TS3500 tape library strings. This flexibility also accommodates constrained data center layouts that do not have room to expand on the x-axis, and data centers with large archives that exceed the maximum cartridge count of an individual TS3500 tape library string.

Drive sharing across library resources

As shown in Figure 1-20, the TS3500 tape library Shuttle Complex can move tapes from one library string to another by bypassing the intermediate library strings in comparison to a traditional pass-through method. The TS3500 tape library transports tape cartridges in shuttle cars that pass over the libraries. This method of transporting cartridges is called *direct flight*. With the direct flight capability, if there is no drive available in the home logical library; the cartridge is moved across a *shuttle connection* to a logical library with an available drive. This configuration of interconnected parallel library strings is called a *shuttle complex*.

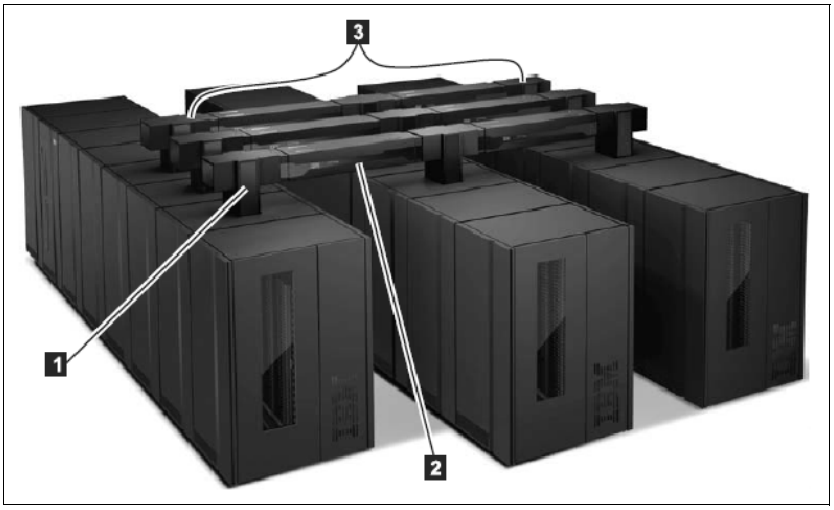


Figure 1-20 TS3500 tape library shuttle complex

The following components of a shuttle complex are shown in Figure 1-20:

1. Shuttle stations

   The shuttle station mounts on top of an HD frame. It consists of a base pad and a shuttle slot. The shuttle slot docks into the base pad. When the shuttle slot is all the way down into the frame station, it can accept or deliver a cartridge. Each shuttle station has its own import/export element (IEE) address.

2. Shuttle span

One or more shuttle spans are linked together to form a shuttle connection between HD frames in parallel library strings. Shorter shuttle spans support distances between library strings ranging from 762 mm (30 inch) to 1524 mm (60 inch). Longer shuttle spans support distances between library strings ranging from 1524 mm (60 inch) to 2743.2 mm (108 inch).

3. Shuttle connection

   A shuttle connection consists of one shuttle car, two or more shuttle stations, and one or more spans between these shuttle stations. Each shuttle connection supports one shuttle car.

For more information about the TS3500 tape library Shuttle Complex, see 10.1.3, “TS3500 tape library storage only frames S24 and S54” on page 300.

HPSS overview

High Performance Storage System (HPSS) is cluster-based software that provides for overall management and access of many petabytes of data. HPSS is capable of concurrently accessing hundreds of disk arrays and tape drives for extremely high aggregate data transfer rates, thus enabling HPSS to easily meet otherwise unachievable demands of total storage capacity, file sizes, data rates, and number of objects stored.

HPSS has been used successfully for digital image libraries, scientific data repositories, university mass storage systems, and weather forecasting systems, and defense and national security applications.

A High Performance Computing (HPC) system needs a high performance storage system, and that is what HPSS offers. HPSS is installed in some of the greatest HPC systems worldwide, including ORNL Titan, LLNL Sequoia, RIKEN K-Computer, ANL Mira, CEA Curie Thin Nodes, and NCAR Yellowstone.

HPSS is the result of the collaboration of the following institutions:

- IBM Global Services in Houston, Texas
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Oak Ridge National Laboratory
- Sandia National Laboratories

The collaborative development is important because the developers are users of the technology.

HPSS can provide an extremely scalable repository for content management software systems, including the integrated Rule Oriented Data Systems (iRODS) and IBM FileNet®. HPSS can be used alone, with its own interfaces, or it can be used to provide space management and disaster recovery backup for the IBM General Parallel File System (GPFS™).

For more information about HPSS, see 10.1.6, “High Performance Storage System” on page 317 or the *IBM System Storage® Solutions Handbook,* SG24-5250.

The IBM TS4500 tape library

The IBM TS4500 is a highly scalable, stand-alone tape library that provides high-density tape storage and high-performance, automated tape handling for open systems environments.

Figure 1-21 shows a three-frame version of the TS4500 tape library. An individual library consists of one base frame and up to three expansion frames and can include up to 60 tape drives and more than 4,500 tape cartridges.



Figure 1-21 TS4500 introduction

The TS4500 tape library provides the following capabilities:

- All frames include high-density (HD) slot technology
- Additional frame models can be placed in any active position so that the library can grow from both the right side and the left side of the first L frame
- Integrated management console (IMC)
- New user interface for improved usability
- Updated control system
- Input/output (I/O) magazine to allow individual cartridge handling to be performed independent of the library
- Top-rack space to house extra tape solution components within the library footprint
- Support for HD2-compatible models of the TS1150 (3592 EH8), TS1140 (3592 EH7), LTO 5 (3588 F5C), and LTO 6 (3588 F6C) tape drives

The TS4500 tape library is available with several tape drive, frame model, and feature options to meet your specific needs. Additional features of the TS4500 tape library are highlighted in the following list:

- Advanced Library Management System (ALMS)
- Ability to attach multiple simultaneous heterogeneous servers
- Remote management with the TS4500 management GUI or the TS4500 command-line interface (CLI)
- Remote monitoring using Simple Network Management Protocol (SNMP), email, or syslog
- Multipath architecture
- Drive and media exception reporting
- In-depth reporting using the Tape System Reporter (TSR)
- Host-based path failover
- Up to 144 I/O slots (36 I/O slots standard for LTO libraries and 32 I/O slots standard for 3592 libraries)

For more information about TS4500, see the *IBM TS4500 Tape Library Guide*, SG24-8236.

1.4 Tape solutions in a SAN environment

Connectivity to tape is essential for most backup processes. However, manual tape operations and tape handling are expensive. Studies show that automation of tape processing saves money and increases reliability. Enterprises have long had to use staff to remove these tapes, transport them to a storage site, and then return them to the tape drive for mounting when necessary. Client tape planning initiatives are directed at more efficient use of drives and libraries and at minimization of manual labor that is associated with tape processing.

The biggest challenges with SCSI tape implementations are the limited cable length and the limited possibilities to share drives between several systems. For LVD SCSI, the total cable length is limited to 25 m (82 ft.) that uses point-to-point interconnection (such as one host connected to only one tape drive). With multidrop interconnection (one host connected to more than one tape drive on the same SCSI bus), the total cable length is 12 m (39.4 ft.) for LVD SCSI and 25 m (82 ft.) for High Voltage Differential (HVD) SCSI. Most SCSI tape drives have only one SCSI port and, therefore, can be attached only on one SCSI bus. This method severely limits the number of hosts that can physically use the drive without recabling.

SANs enable greater connectivity of the tape libraries and tape drives and enable tape sharing. With Fibre Channel, the distance between the server (or *data point*) and the connected tape node can be up to 10 km. Fibre Channel enables multiple host scenarios without recabling.

If software to manage tape-drive sharing is unavailable, you must isolate (or *zone*) the drives to unique hosts by using functions that are commonly available on SAN gateways or switches. With the correct management software, each drive can communicate with each host, and connections can be dynamic without recabling.

Backup solutions can use SAN technology several ways to reduce the costs of their implementation while increasing their performance.

Sharing tape devices in a SAN environment

The tape world has the following distinct means of sharing:

- Library sharing
- Drive sharing
- Media sharing

Library sharing

Library sharing occurs when multiple servers that are attached to a tape library share the library and the robotics. Tape drives within the library might or might not be shared (*pooled*) among the attached servers. Tape library sharing is a prerequisite for tape-drive sharing.

Drive sharing

The sharing of one or more tape drives among multiple servers is called *drive sharing*. To share drives between heterogeneous applications within a tape library, the tape library must provide multiple paths to the robotics and be able to define the drives and slots of a library as multiple logical libraries. The server that is attached to each logical library has no knowledge of any drives or slots outside the logical library.

Media sharing

Media sharing today is possible only in a homogeneous environment between servers that use the same backup server and the same library to back up their data. For systems that are not backed up by the same backup server, it is possible to share only a tape scratch pool.

1.5 Tape virtualization for open systems

A *virtual tape library* (VTL) is a unique blend of several storage tiers. The lifecycle of data starts with its creation at the server tier, then migrates by backup software to a VTL tier. You now have many options for the data because the VTL is a combination of high performance SAN-attached disk and high performance servers that are running Linux, which emulates a tape storage device.

With disk prices falling and the need to recover data quickly increasing, more organizations started adopting disk as a viable alternative to slower, more resource-intensive magnetic tape in their backup and recovery environments. Any business that has a need for high performance backup and restore might need virtualization solutions. Only the disk storage tier can provide instant access backup/restore capabilities. All backup software products were designed to back up data to tape drives and libraries, and a VTL emulates tape. You can go directly to a VTL and have your backups completed quickly.

VTLs fill a void in the backup infrastructure for data that needs to be restored at a certain moment. Most restores often happen within six weeks of the data being backed up. Backup software can be configured to back up data to a VTL and then create a tape-to-tape virtual copy for off-site deployment. It is no longer necessary to call the tapes back from an off-site location, unless data is required from years past. However, to meet the requirements of the enterprise data center, a VTL must do more than simply reduce storage requirements. To be viable, it must maintain high sustained throughput performance and meet the availability demands of the enterprise. The TS7650G deduplication gateway from IBM is an example of a deduplicating VTL that meets the demands of the enterprise data center. It is the first solution that supports a cluster of two nodes while sustaining high performance, inline deduplication.

VTLs are used in the same way that physical tape devices are used. The VTL is inserted as a staging area between the first-line disk devices and the tape libraries. From then on, it appears to the backup and recovery software to be a physical tape library with physical drives. This placement changes the physical paradigm for backups from disk-to-tape to disk-to-disk-to-tape (D2D2T), a shift that has interesting consequences.

All VTLs perform the same basic functions, serving as a disk-based target for the backup process, and offering rapid recoveries from local disk-based storage. However, all VTLs are not equal. Users of first-generation VTLs, which use a disk-to-disk (D2D) backup model, found that as their data protection needs increased, they ran out of disk capacity quickly. Additionally, many VTLs provide value through more features such as encryption, compression, and data deduplication.

The use of virtual tapes for backup reduces failure rates allows for smaller backup windows and significantly speeds up recovery. The VTL solution offers the following benefits:

- Increased restore speed
- Reduced cost of online storage
- Improved reliability of the storage environment
- Assured data security
- Reduced time spent managing backups

1.5.1 ProtecTIER virtual tape

The IBM ProtecTIER Virtual Tape service emulates traditional tape libraries. By using this tool, you can move to disk backup without having to replace your entire backup environment. Your existing backup application can access virtual robots to move virtual cartridges between virtual slots and virtual drives. The backup application perceives that the data is being stored on cartridges while ProtecTIER actually stores data on a deduplicated disk repository on the storage fabric. Figure 1-22 shows the concept of virtual tape.

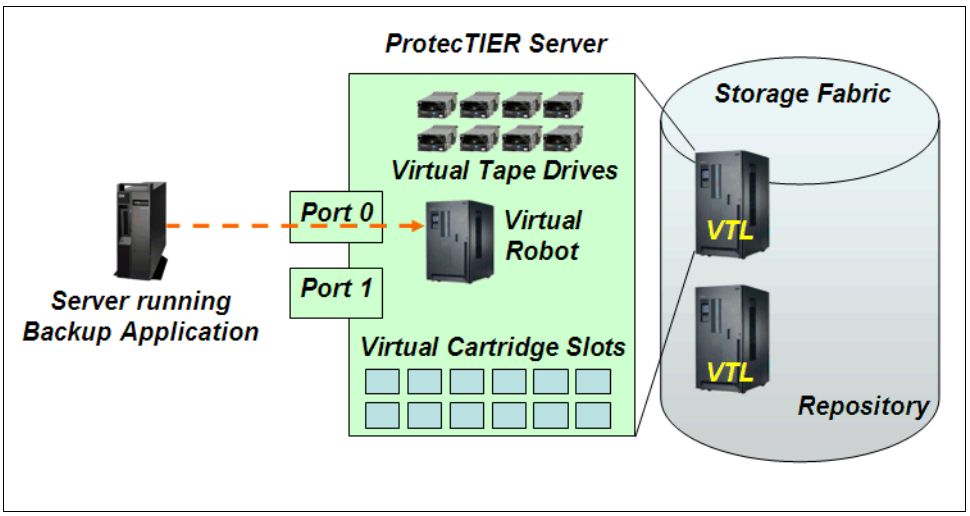


Figure 1-22 ProtecTIER virtual tape concept

In addition, tape virtualization ProtecTIER provides the following main features:

- Data deduplication
- ProtecTIER native replication

Each of these features brings its own set of options to customize to your environment. The ProtecTIER software is configured by and ordered from IBM or its business partners. The order includes the ProtecTIER and the ProtecTIER Manager GUI application.

1.5.2 Data deduplication

While VTLs are now a fundamental element of the data center infrastructure, the growth of data under management is outpacing the ability of most firms to add disk capacity to their VTLs. This phenomenon has led to a strong demand for data deduplication. Data deduplication is a technology that finds and eliminates redundant data within a disk repository. The effect is a dramatic increase in the usable capacity of a given disk pool. By combining this powerful technology with VTLs, firms can store and retain far more data than they were previously able to, while saving significantly on disk storage costs.

Data deduplication refers to the elimination of redundant data. In the deduplication process, duplicate data is deleted, leaving only one copy of the data to be stored. However, indexing of all data is still retained if that data is ever required. Deduplication can reduce the required storage capacity because only unique data is stored. This task is achieved by storing a single copy of data that is backed up repetitively. Data deduplication can provide greater data reduction than previous technologies, such as Lempel-Ziv (LZ) compression and differencing, which is used for differential backups.

By reducing the amount of data under management, data centers reduce the amount of hardware that is required, thus decreasing operational expenses for power and cooling. Data centers also reduce tape media costs and make it easier for storage administrators to cope with drastic increases in raw data and increased complexity in the rest of their storage infrastructures. Figure 1-23 shows the basic components of data deduplication for the IBM TS7650 ProtecTIER server.

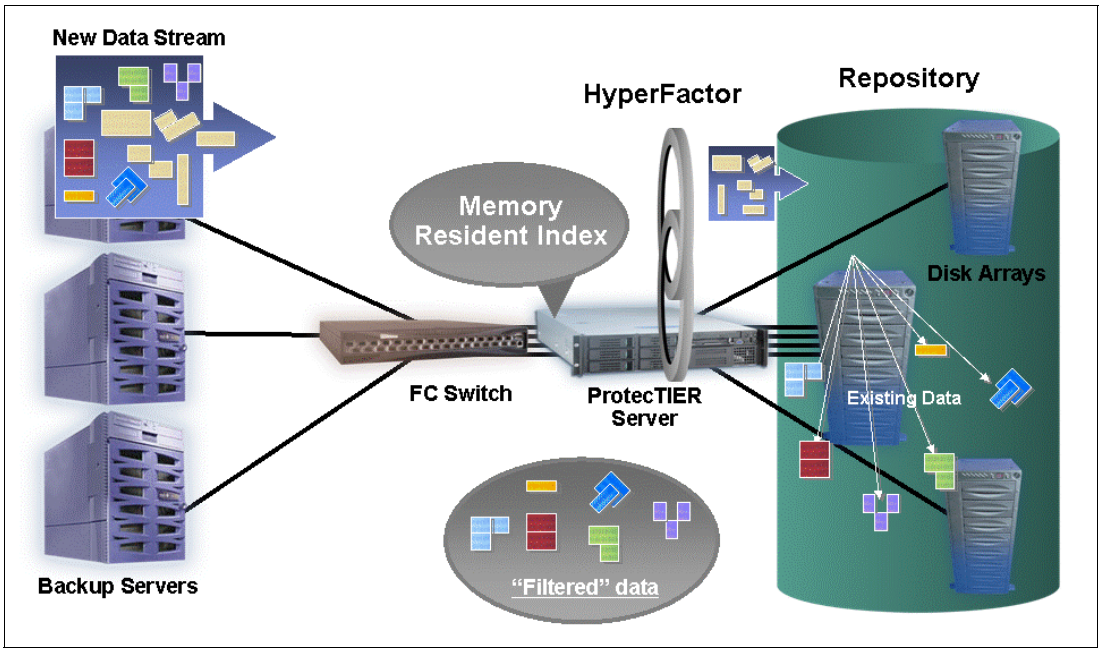


Figure 1-23 Deduplication concept

With data deduplication, data is read by the data deduplication system, which breaks the data into elements or chunks. The deduplication process creates a signature or identifier for each data element. Whether inline or post processing data deduplication is used, data element signature values are compared to identify duplicate data. After the duplicate data is identified, one copy of each element is retained, pointers are created for the duplicate items, and the duplicate items are not stored.

The effectiveness of data deduplication depends upon many variables, including the rate of data change, the number of backups, and the data retention period. For example, if you back up the same uncompressible data once a week for six months, you save the first copy and do not save the next 24, which provides a 25:1 data deduplication ratio.

If you back up an uncompressible file in week one, back up the exact same file again in week two and never back it up again, you have a 2:1 deduplication ratio. A more likely scenario is that some portion of your data changes from backup to backup so that your data deduplication ratio changes over time. For example, you take weekly full and daily differential incremental backups. Your data change rate for the full backups is 15%, and your daily incrementals are 30%. After 30 days, your deduplication ratio might be around 6:1. However, if you kept your backups up to 180 days, your deduplication ratio might increase to 10:1.

Different data deduplication products use different methods of breaking up the data into elements, but each product uses a technique to create a signature or identifier for each data element. The IBM TS7650 uses the HyperFactor® Deduplication Engine to perform high-speed pattern matching.

1.5.3 HyperFactor

The cornerstone of ProtecTIER is IBM HyperFactor, the technology that deduplicates data inline as it is received from the backup application. The bandwidth efficient replication, inline performance, and scalability of ProtecTIER directly stem from the technological breakthroughs that are inherent in HyperFactor. HyperFactor is based on a series of algorithms that identify and filter out the elements of a data stream that were stored by ProtecTIER.

IBM HyperFactor uses its algorithms to perform high-speed pattern matching, identifying, and eliminating of instances of duplicate data. This method reduces the total amount of stored data (and thus the need to buy more storage) by up to 25:1, depending on the environment.

HyperFactor can reduce any duplicate data, regardless of its location or how recently it was stored. Unlike hash-based techniques, HyperFactor finds duplicate data without needing exact matches of chunks of data. When new data is received, it checks to see whether similar data already was stored. If so, only the difference between the new data and previously stored data must be retained. This technique of finding duplicate data performs well.

With this approach, HyperFactor can surpass the reduction ratios that are attainable by any other data reduction method.

1.5.4 File System Interface

The File System Interface (FSI) is a feature that was implemented in ProtecTIER server version 3.2. The ProtecTIER FSI emulates Windows file system behavior and presents a virtualized hierarchy of file systems, directories, and files to Windows CIFS clients. Clients can perform all Windows file system operations on the emulated file system content. The ProtecTIER FSI interface is intended to be used for backup and restore of data sets by using a backup application. It is single-node only, and FSI/CIFS cannot be deployed on dual-node clusters.

1.5.5 ProtecTIER models

IBM currently offers two virtualization solutions for open systems: The TS7650G (3958) gateway and the TS7620 appliance IBM Express® (3959 SM2).

Note: IBM offered a TS7650 ProtecTIER Appliance model (3958 AP1), but has since been withdrawn from marketing. It is described here for reference purpose only.

TS7650G ProtecTIER Deduplication Gateway

The TS7650G does not include a disk repository and consists of the following components:

- 3958 DD5

  This is the latest model available from May 2012, which shipped with the ProtecTIER server software version 3.3 or higher. This server is based on the x7145 type. When it is ordered as the ProtecTIER TS7650G, the machine type and model are 3958 DD5.

- 3958 DD4

  This is a higher performance server than the DD3 and was available from November 2010.

- 3958 DD3

  This is an improved performance server over the previous version and has been available since March 2009.

- 3958 DD1

  This is the original server introduced in August 2008. This server is based on the IBM System x3850 M2 Type 7141. When used as a server in the TS7650G, its machine type and model are 3958 DD1.

- System console

  The system console is a TS3000 System Console (TSSC). This document uses the terms s*ystem console* and *TSSC* interchangeably.

The TS7650G gateway solution also connects to the Disk subsystem. The customer chooses the disk subsystem for use with the TS7650G. A list of compatible controllers is available at the IBM Tape Systems Resource Library at this website:

`http://www.ibm.com/systems/storage/tape/library.html`

Verify compatibility in the TS7650/TS7650G ISV and the interoperability matrix document on the website.

TS7620 ProtecTIER Appliance Express

The TS7620 appliance is based on machine type 3959. The model is SM2. The IBM ProtecTIER Entry Edition software is loaded on the IBM TS7620 ProtecTIER Deduplication Appliance to create a valid TS7620 ProtecTIER Deduplication Appliance solution. A separate order for ProtecTIER Entry Edition is required. Clients can choose between VTL configuration, OpenStorage (OST), or the File System Interface (FSI), which supports Common Internet File System (CIFS) as a backup target.

The TS7620 appliance uses the 3959 SM2 server. The 3959-SM2 is a rack unit (2U) bundled appliance. It comes together with the disk storage and the ProtecTIER software in a 2U device. With the rail kit, it is 3U. The following levels of disk capacity can be ordered:

- 6 TB (base, software limited)
- 12 TB (base, software full capacity)
- 23 TB (base, software full capacity plus expansion 1)
- 35 TB (base, software full capacity plus expansion 1 and 2)

TS7650 ProtecTIER Deduplication Appliance

The TS7650 Appliance includes a disk repository and consists of the following components:

- Server

  The 3958 AP1 server is based on an IBM System x3850 X5 Type 7145-AC1 with ProtecTIER version 3.3.

- The system console

  The system console is a TS3000 System Console (TSSC).

- Disk controller

  This controller is a 4.8 TB Fibre Channel Disk Controller.

- Disk expansion unit

This controller is a 7.2 TB Fibre Channel Disk Expansion Unit.

For more information about ProtecTIER, see 11.5, “TS7620 ProtecTIER Deduplication SMB Appliance” on page 379.

1.6 Linear Tape File System

IBM addressed the growing storage needs of marketplace segments such as Media and Entertainment by introducing the first release of Linear Tape File System (LTFS) in 2010. IBM developed LTFS Single Drive Edition (SDE) to enable a self-describing cartridge that is based on dual partition in the LTO-5 technology. LTFS is a true file system that makes tape look and work like any removable media. LTFS SDE is available as a free download from Fix Central for single LTO-5 or LTO-6 tape drives at this website:

http://www.ibm.com/support/fixcentral

In May of 2011, IBM announced IBM LTFS Library Edition (LE) system support for tape automation for TS3100, TS3200, and TS3500 tape libraries. IBM followed up in July of 2011 by announcing support for TS2900 tape autoloader and TS3310 tape library and has since added the TS4500 tape library to the supported list.

LTFS LE provides the ability to create a single file system mount point for a logical library that is managed by a single instance of LTFS, which runs on a single computer system. In addition, it provides for caching of tape indexes, and for searching, querying, and displaying tape contents within an IBM tape library without the requirement to mount tape cartridges. In October 2012, updated versions of LTFS SDE and LTFS LE were announced.

In June 2012, IBM announced IBM LTFS Storage Manager, which adds functionality to LTFS LE. The LTFS Storage Manager is a software solution that manages and monitors the archive and restore of files in an LTFS-based automated tape library. The Storage Manager efficiently achieves these functions by maintaining an index of all files in the library by using an IBM DB2® back end. This multi-format file management application is focused on processing and archiving media files in the broadcasting domain; however, it is not limited to this field. The LTFS Storage Manager can manage any type of file and is useful in many applications, in addition to broadcasting.

In 2013 IBM announced IBM LTFS Enterprise Edition (EE). With the introduction of LTFS EE and the enterprise-level management of GPFS, tape now addresses the primary concerns of organizations requiring scalable tiered data, ease of scalability, improved I/O and transactional performance, improved data availability, and faster deployment and provisioning times.

LTFS EE combines the ease of use of LTFS with the scalability, manageability and performance of IBM General Parallel File System (GPFS), long an industry leader in high availability and high input/output (I/O) capabilities. LTFS EE extends GPFS abilities, however, with simplified tape administration. LTFS EE relieves the complexity of transferring data from tiered disk storage to tape. For organizations of any size, the result is the ability to move beyond simply adding storage to optimizing and streamlining data management, while also reducing the costs of storage infrastructure and power

The importance of LTFS to the storage industry was highlighted by the following awards:

- National Association of Broadcasters Show Pick Hit, 2011

  http://bit.ly/1xSJ7ej
- National Association of Broadcasters Show Pick Hit, 2011

  http://www.ibm.com/press/us/en/pressrelease/35743.wss
- Storage Visions' Visionary Media and Entertainment Company Award, 2012

  http://www.storagevisions.com/2012Awards.htm

1.6.1 LTFS Single Drive Edition

LTFS is the first file system that works with LTO generation 5, LTO generation 6, TS1150, and TS1140 tape technology to set a new standard for ease-of-use and portability for open systems tape storage. These tape drives support Media Partitioning, which allows their media to be divided in segments. This ability improves accessibility by providing the ability to quickly locate data to retrieve or update.

IBM has created LTFS as a self-describing tape file system on standard format to implement a true file system for tape. LTFS SDE is a self-describing tape format and open source file system software. Combined with LTO-5 and LTO-6 partitioning technology, it brings functionality for easy handling of the tape drives.

LTFS can write files directly to tape media without any specific application. The tape drive shows up on the operating system as though it were a USB-attached drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. Users can run any application that is designed for disk files against tape data without concern for the fact that the data is physically stored on tape.

Figure 1-24 shows how easy it is to manage the files that are stored on the LTO-6 cartridge by using the LTFS graphical user interface.

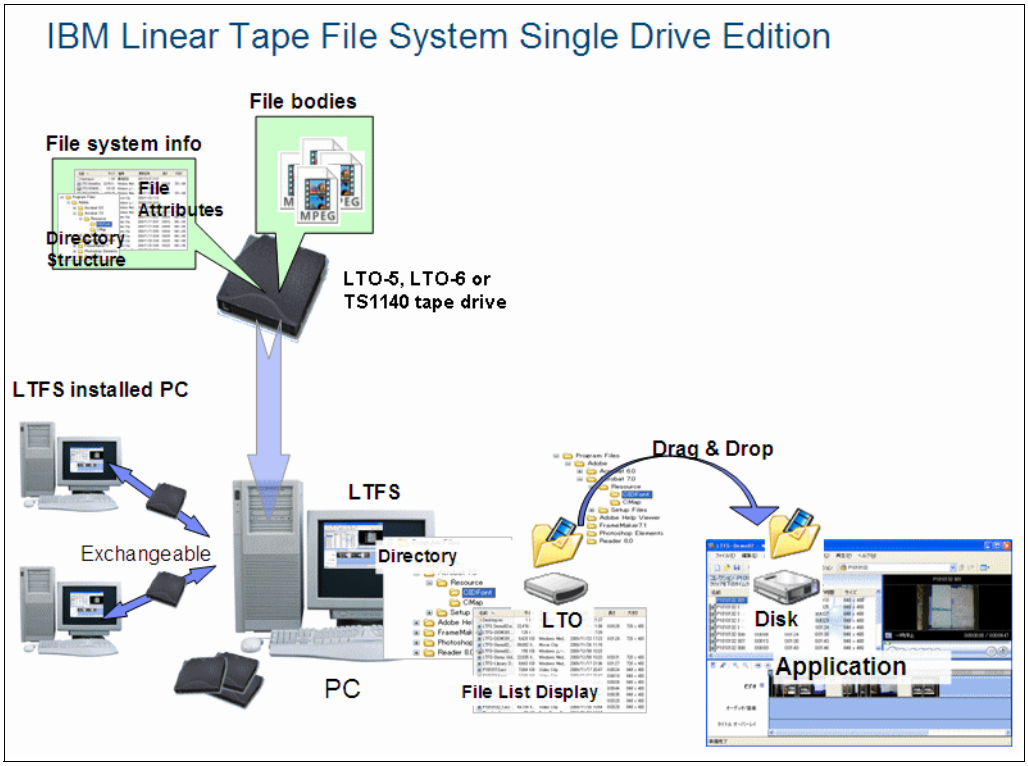


Figure 1-24 LTFS SDE overview

For more information about LTFS SDE, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

1.6.2 LTFS Library Edition

The recent announcement of IBM LTFS LE extends the File Manager capability of LTFS SDE. Built on the LTO Ultrium 5 format standard, LTFS LE provides a direct, intuitive, graphical access to data that is stored in IBM tape drives and libraries by using LTO generation 5 or 6

tape cartridges. Also, the TS1150 and TS1140 tape drive supports partitioned media and will support LTFS LE on a TS3500 and TS4500 tape library or IBM Linear Tape-Open (LTO) Ultrium 6 and 5 tape drives that are installed in the TS3310 tape libraries.

LTFS LE provides the following benefits:

- The graphical user interface helps reduce complexity by enabling an icon-based view of the tape library, including tape cartridges and files by using the operating system's file manager.
- It helps reduce costs because it does not require any other tape management software or utilities.
- The file system API of the operating system is used to provide a basic read/write interface to the tape library for applications without any other operating system enhancements, such as plug-ins or service packs.
- "Mount-less" cartridge inquiry for fast access is achieved after the tape library is inventoried. Tape cartridges do not have to be remounted to retrieve content index data and basic cartridge information, such as volume name and serial number.
- LTFS LE software can be ordered concurrently with hardware or as software only for installed supported tape libraries.

Figure 1-25 shows how LTFS LE presents the tapes in the library as folders.

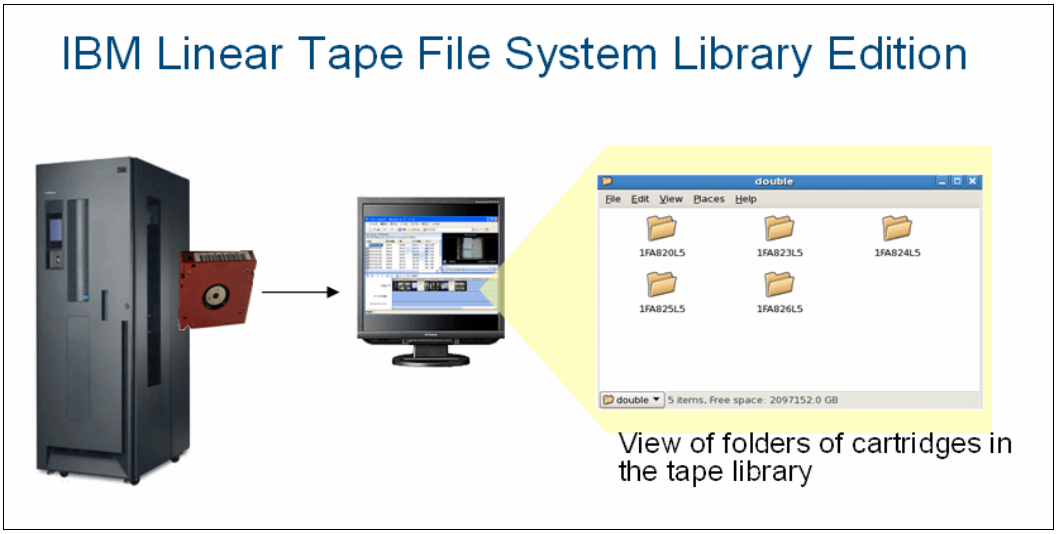


Figure 1-25 LTFS LE view of tape folders

The following IBM tape libraries and tape autoloader support LTFS LE:

- TS2900 tape autoloader
- TS3100 tape library
- TS3200 tape library
- TS3310 tape library
- TS3500 tape library
- TS4500 tape library

For more information about LTFS LE, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

1.6.3 IBM Linear Tape File System Enterprise Edition (EE)

IBM Linear Tape File System Enterprise Edition (LTFS EE) for the IBM TS4500, IBM TS3500, and IBM TS3310 tape libraries provides seamless integration of LTFS with IBM General Parallel File System (GPFS) by creating an LTFS tape tier. You can run any application that is designed for disk files on tape by using LTFS EE. It can play a major role in reducing the cost of storage for data that does not need the access performance of primary disk.

With LTFS EE, you can enable the use of LTFS for the policy management of tape as a storage tier in a GPFS environment and use tape as a critical tier in the storage environment. LTFS EE supports IBM Linear Tape-Open (LTO) Ultrium 6 and 5 tape drives, and IBM TS1150 and TS1140 tape drives that are installed in TS4500 and TS3500 tape libraries or LTO Ultrium 6 and 5 tape drives that are installed in the TS3310 tape libraries.

The use of LTFS EE to replace disks with tape in Tier 2 and Tier 3 storage can improve data access over other storage solutions because it improves efficiency and streamlines management for files on tape. LTFS EE simplifies the use of tape by making it not apparent to the user and manageable by the administrator under a single infrastructure.

Figure 1-26 shows the integration of LTFS EE archive.

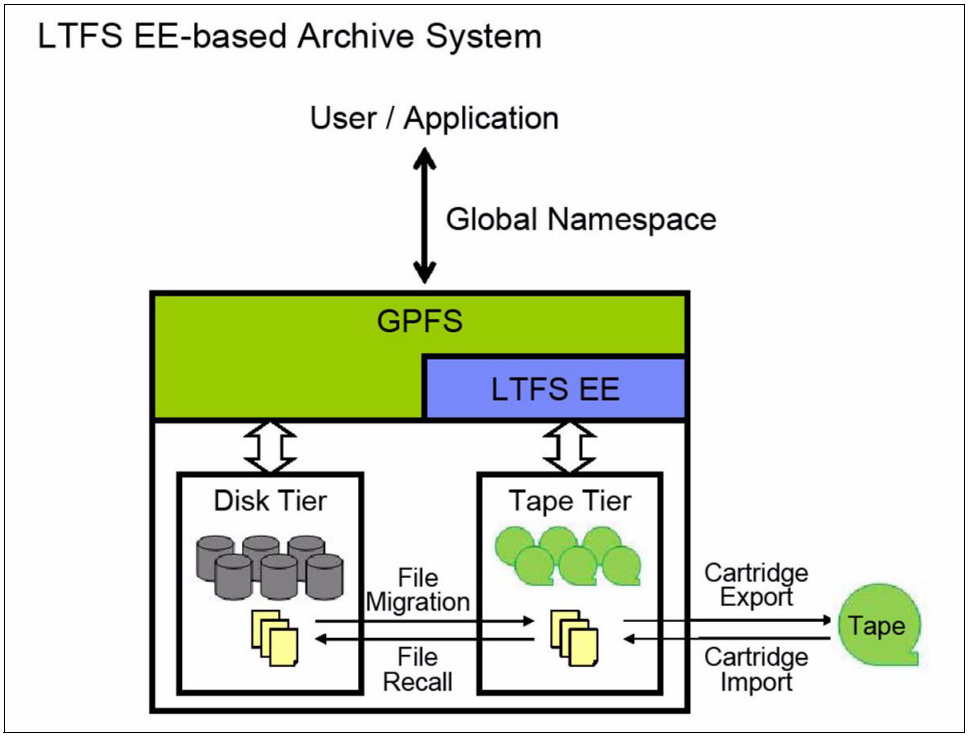


Figure 1-26 High-level overview of LTFS EE archive

LTFS EE uses an enhanced version of the LTFS Library Edition, which is referred to as *the LTFS LE+ component*, for the movement of files to and from tape devices. The scale-out architecture of LTFS EE provides the ability to add nodes and tape devices as needed to satisfy bandwidth requirements between GPFS and the LTFS tape tier.

Low-cost storage tier, data migration, and archive needs that are described in the following use cases can benefit from LTFS EE:

- Operational storage

  Provides a low-cost, scalable tape storage tier.

- Active archive

  A local or remote LTFS Library Edition node serves as a migration target for GPFS that transparently archives data to tape that is based on policies set by the user.

The following LTFS EE characteristics cover a broad base of integrated storage management software with leading tape technology and the highly scalable IBM TS4500, TS3500, and TS3310 tape libraries:

- Includes the standard LTFS Library Edition with its supported tape drives (TS1150, TS1140, LTO 5, and LTO 6) in the TS4500 and TS3500 or only LTO 5 and LTO 6 in the TS3310.
- Integrates with GPFS similar to IBM Tivoli Storage Manager Hierarchical Storage Management (HSM) by supporting file-level migration and recall with an innovative database-less storage of metadata.
- Provides a scale out architecture that supports multiple LTFS EE nodes that share the same tape inventory with load balancing over multiple tape drives and nodes.
- Enables tape cartridge pooling and data exchange for LTFS tape tier management:
  - Tape cartridge pooling allows the user to group data on sets of tape cartridges
  - Multiple copies of files can be written on different tape cartridge pools.
  - Support tape cartridge export with and without removal of file metadata from GPFS.
  - Support tape cartridge import with prepopulation of file metadata in GPFS.

LTFS EE provides the following benefits:

- A low-cost storage tier in a GPFS environment.
- An active archive or big data repository for long-term storage of data that requires file system access to that content.
- File-based storage in the LTFS tape format that is open, self-describing, portable, and interchangeable across platforms.
- Lowers capital expenditure and operational expenditure costs by using cost-effective and energy-efficient tape media without dependencies on external server hardware or software.
- Supports the highly scalable automated TS4500, TS3500, and TS3310 tape libraries.
- Allows the retention of data on tape media for long-term preservation (10+ years).
- Provides the portability of large amounts of data by bulk transfer of tape cartridges between sites for disaster recovery and the initial synchronization of two GPFS sites by using open-format, portable, self-describing tapes.
- Migration of data to newer tape and or newer technology that is managed by GPFS.
- Provides ease of management for operational and active archive storage.

Tip: For a free trial version of the LTFS EE, contact your local IBM sales representative.

For more information about LTFS EE, see *IBM Linear Tape File System Enterprise Edition V1.1.1.2 Installation and Configuration Guide, SG24-8143.*

1.6.4 LTFS Storage Manager

The LTFS Storage Manager is software that manages and monitors archiving and restoring files in an LTFS LE-based automated tape library. The Storage Manager efficiently achieves these functions by maintaining an index of all files in the library by using a DB2 back end. This

multiformat file management application is focused on processing and archiving media files in the broadcasting domain; however, it is not limited to this field. The LTFS Storage Manager can manage any type of file and is useful in many applications, in addition to broadcasting.

The LTFS Storage Manager provides a web service application programming interface (API) that uses the SOAP to start archive, restore, and other management operations and to monitor their progress. The API also offers the ability to search for files based on their metadata. The LTFS Storage Manager web client can be used to manually start operations and to query the content of the archive, in addition to general administration of the system. The Storage Manager also can be configured to monitor folders on a file system, detect new files, and archive them automatically.

For more information about LTFS SM, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

1.7 IBM Tape System Library Manager

IBM Tape System Library Manager Version 1.1 (TSLM) expands and simplifies the use of IBM TS3500 tape libraries by providing a consolidated view of multiple libraries that are capable of storing up to 2.7 Exabytes. The tape pathing maintenance and definitions can be reduced by up to 75%.

TSLM provides a resource management layer between applications, such as Tivoli Storage Manager and the tape library hardware. Essentially, TSLM decouples tape resources from applications, which simplifies the aggregation and sharing of tape resources.

TSLM provides the following benefits:

- Consolidated, mainframe-class media management services.
- Centralized repository, access control and administration.
- Management beyond physical library boundaries:
  - Access multiple TS3500 tape libraries as a single library image
  - TS3500 tape libraries can be separate (at SAN distances) or connected in a shuttle complex
- Dynamic sharing of resources across heterogeneous application boundaries.
- Security features to permit or prevent application access to tapes:
  - Helps to enable common scratch pool and private pools for every application
  - Ensures secure use and visibility
- Policy-based drive and cartridge allocation.
- Policy-based media-lifecycle management.
- Tivoli Storage Manager enhancements:
  - Simplified path management in Tivoli Storage Manager
  - Simplified device sharing
- 3494 Emulation of an IBM 3494 library on top of an attached TS3500 library.

Figure 1-27 shows the architecture.

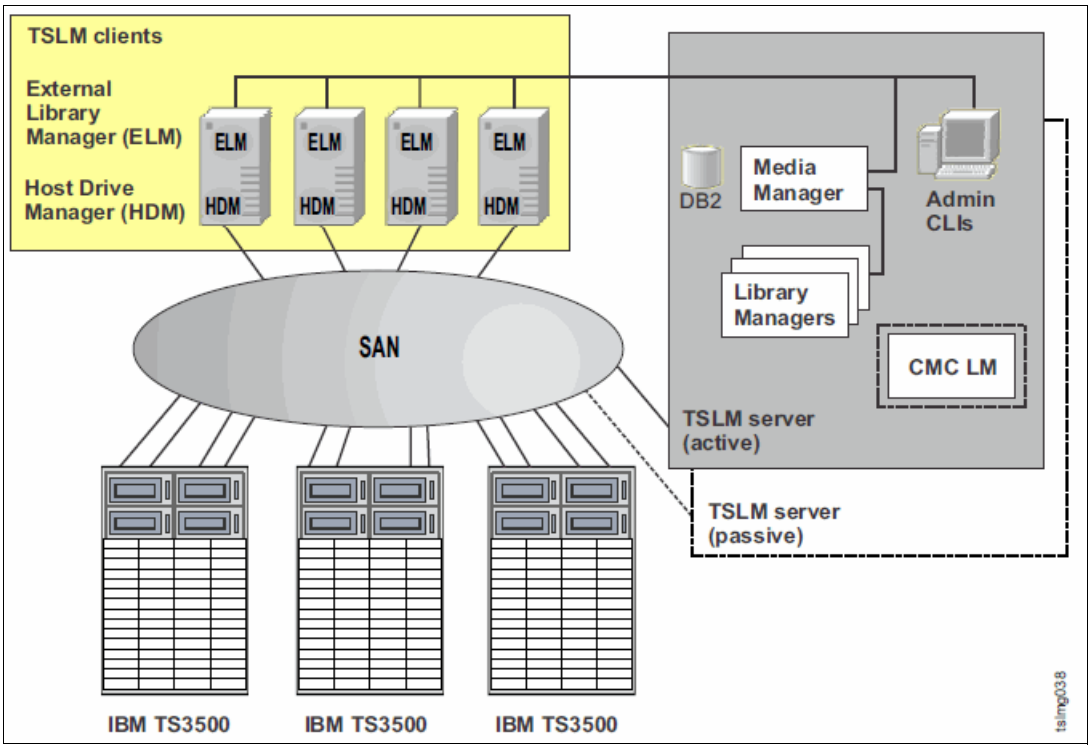


Figure 1-27 IBM Tape System Library Manager architecture

TSLM is composed of the following modules with specific functions:

- Media Manager

  The Media Manager (MM) is the central server component which, among other tasks, coordinates access to drives and cartridges, handles volume allocation and deallocation requests, and stores a log of all activities. The MM uses a TSLM bundled (and constrained) version of IBM DB2 for persistent storage.

- Library Manager

  The Library Manager (LM) provides the MM access to library media changers. The LM reports all slots, tape drives, and cartridges to the MM, controls libraries on behalf of the MM, and encapsulates (that is, virtualizes) the library hardware. Because of this virtualization, new library hardware can be integrated into TSLM without any changes to an installed MM.

- Library Manager for CMC

  The Library Manager for Connected Media Changer (CMC LM) provides the MM with control of the TS3500 tape library Shuttle Complex. The CMC LM discovers shuttle connections and controls movement of cartridges from one library to another by using shuttle connections.

- Host Drive Manager

  The Host Drive Manager (HDM) reports all local device handles to MM, runs mount and unmount commands, checks the path before a cartridge is loaded, and reports statistical data to MM when a cartridge is unloaded.

- External Library Manager

  The External Library Manager (ELM) serves as a management layer between Tivoli Storage Manager and the TSLM Media Management software. It translates the Tivoli Storage Manager External Media Management Interface (EMMI) API into commands of the IEEE 1244 Media Management Protocol that is understood by TSLM. The ELM executable file must be on the same server that runs the Tivoli Storage Manager server for TSLM because the Tivoli Storage Manager server directly runs the ELM executable file. The ELM executable file communicates with TSLM over a TCP/IP connection.

For more information about this product, see Chapter 12, “Library management” on page 423 and *IBM Tape System Library Manager Version 1 Release 1 User’s Guide*, GA32-2208.

2

Overview of IBM LTO Ultrium tape drives

The Linear Tape-Open (LTO) program was conceived as a joint initiative of IBM, Hewlett-Packard, and Seagate Technology. In 1997, the three technology provider companies set out to enable the development of best-of-breed tape storage products by consolidating state-of-the-art technologies from numerous sources. In November 1997, they produced a joint press release about LTO technology. The three technology provider companies for LTO technology are now Hewlett-Packard (HP), IBM Corporation, and Quantum.

In the tape storage industry, the member companies saw a common set of problems affecting clients in the midrange and network server areas. Multiple tape options were available, each offering certain strengths in terms of capacity, performance, data integrity, reliability, and cost, but no single option seemed to meet all of these client needs effectively. The objective of LTO technology was to establish new open-format specifications for high-capacity, high-performance tape storage products for use in the midrange and network server computing environments and to enable superior tape product options.

This chapter provides information about the LTO format specifications in general terms, including first, second, third, fourth, fifth, and sixth generation Ultrium technologies. The documented LTO specification includes information referring to the data cartridge, the format in which data is written, elements of the drive specification relating to that format, and the compression algorithm description. This information applies to all product offerings of LTO manufacturers to ensure cartridge interchangeability.

The information in this chapter that relates to the LTO Ultrium drive also relates to the IBM LTO Ultrium drive. It might differ from information from other manufacturers in regard to features, such as data rate and reliability. This chapter includes the following sections:

- The LTO organization
- Tape encryption overview
- IBM Ultrium 1, 2, 3, 4, 5, and 6 compatibility
- IBM LTO Ultrium 6 tape drives
- IBM LTO Ultrium 5 tape drives
- IBM LTO Ultrium 4 tape drives

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2.1 The LTO organization

For more information about marketing, technical, and licensing details for the Linear Tape-Open program, see the following websites:

- http://www.lto-technology.com
- http://www.ultrium.com

2.1.1 Overview

Two LTO formats (Ultrium and Accelis) were introduced in 1997, and licenses for the technology were made available. Since then, the Accelis format has not been actively pursued by manufacturers because it is apparent that the Ultrium format meets market needs. The three LTO sponsoring companies took steps to protect client investment by providing an Eight-Generation Roadmap that illustrates native capacity (see Figure 2-1). They also established an infrastructure to enable compatibility between products.

Important: Hewlett-Packard, IBM, and Quantum reserve the right to change the information in this migration path without notice.

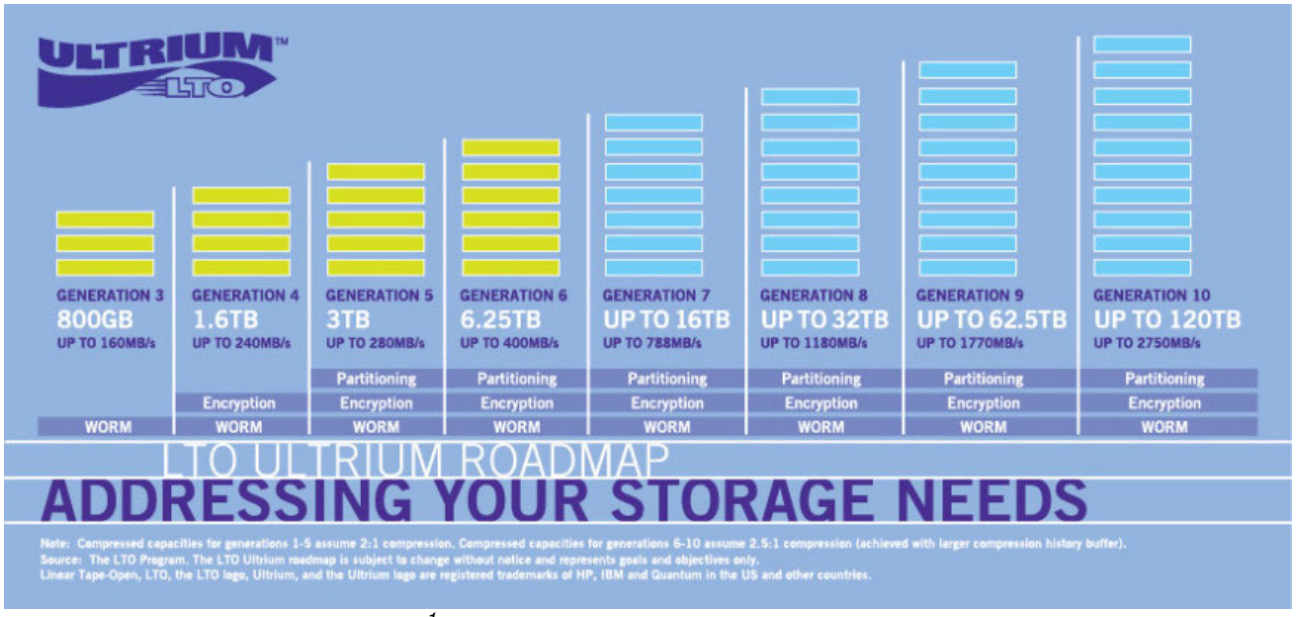


Figure 2-1 Eight-Generation Roadmap[1]

The LTO Ultrium compatibility investment protection is provided based on the following principles:

- An Ultrium drive is expected to read data from a cartridge in its own generation and at least the two previous generations.
- An Ultrium drive is expected to write data to a cartridge in its own generation and to a cartridge from the immediate previous generation in the format of that generation.

For more information about compatibility among the available Ultrium 1, Ultrium 2, Ultrium 3, Ultrium 4, Ultrium 5, and Ultrium 6 media, see 2.3.1, “IBM Ultrium 1, 2, 3, 4, 5, and 6 compatibility” on page 72.

[1] For more information, see LTO Technology at this website: http://www.lto.org/technology/what-is-lto-technology/

The three technology provider companies (HP, IBM, and Quantum) all made significant contributions of time and expertise to the definition of the LTO format specifications. All three companies have deep knowledge of client needs. They provided expert knowledge and engineering skill in the critical areas of magnetic recording technology, mechanism design, media materials, and cartridge design. This cooperative process created stronger LTO format definitions than any of the individual companies might have developed working alone.

Open licensing and manufacturing

To answer industry calls for open-tape format specifications, LTO format specifications were made available to all who want to participate through standard licensing provisions. More than 30 companies, including HP, IBM, and Quantum, became LTO technology licensees. The licensees include an impressive array of worldwide storage industry leaders, including the following companies:

- Accutronics Incorporated
- Advanced Research Corporation
- Alps Electric Company Limited
- Atmel Corporation
- EDP/Colorflex
- EMag Solutions
- Exabyte Corporation
- FalconStor
- FujiFilm Corporation
- Fujitsu Ltd./FCPA Intellistor
- Hewlett-Packard Company
- Hi/fn
- HiStor
- Hitachi Computer Peripherals
- IBM Corporation
- Imation Corporation
- M4 Data Limited
- Matsushita Electric Industry
- Maxell
- Mitsumi Electric Company Limited
- Mountain Engineering II Incorporated
- NEC Corporation
- NXP
- Otari Incorporated
- Ontrack Data International
- Overland Storage
- Plasmon IDE Incorporated
- Quantegy Incorporated
- Quantum Corporation
- Sony Corporation
- Spectra Logic
- Oracle
- Tandberg Data
- TDK Corporation
- Toray
- Verbatim Corporation

In attracting these other industry-leading companies, LTO program technology and LTO specified products (tape drives and tape storage cartridges) can reach the market from multiple manufacturers, not just the technology provider companies. This availability is critical to meeting an open market objective and is accomplished through open licensing of the technology.

License packages

The following combinations of packages are available for potential licensees:

- Ultrium Specification Document provides the opportunity to review the Ultrium format specification with minimal investment and is suitable for companies that are interested in a feasibility investigation.
- Ultrium Tape Cartridge License Package is for companies that are only interested in designing Ultrium tape cartridges.
- Ultrium Tape Mechanism License Package enables licensees to design Ultrium tape drive mechanisms.

Each license package contains one or all of the following types of documents:

- Format specification documentation provides technical information about the format that is necessary to develop mechanisms and cartridges that interchange between products of the same format.
- License documentation provides more technical information about tolerance interdependencies and interchange verification testing. It also provides a conceptual overview of the design.
- The trademark style guide describes the use of the Ultrium trademarks and logos. Figure 2-2 shows an example of an LTO Ultrium logo.



Figure 2-2 Ultrium logo example

More information: For more information about packages, documentation, and licensing, see the following LTO web page:

`http://www.lto.org/licensing/`

Compliance verification

The technical strategy for accomplishing format compliance verification among the licensees was defined and an independent Compliance Verification Entity (CVE) was selected. To promote interchangeability of tape cartridges, a third-party verification test company was enlisted to perform specification compliance verification testing. These tests are required annually for all companies that use the logo.

The objective of the compliance testing is to test only the ability to produce, read, or write Ultrium cartridges that meet the format specifications. The objective of this format compliance testing is not to evaluate Ultrium drive quality, mean time before failure (MTBF), physical form factor, or other parameters that are not directly related to the LTO program formats and interchangeability. LTO program licensees have wide latitude to establish their own mechanical, electrical, and logical designs to meet the format specifications. These factors are not tested as part of the compliance verification process.

2.1.2 LTO standards

LTO technology was originally developed for two open-tape format specifications: Accelis and Ultrium. The Accelis format (fast-access) is not being developed because the Ultrium format provides adequate fast-access performance.

LTO core technology

Multichannel linear serpentine recording is at the core of the LTO formats. It enables an optimum balance of reliability and data integrity, performance, and high capacity. In the LTO recording format, data is written in tracks that run down the length of the tape.

The LTO Ultrium 6 format records data on 2176 tracks across the ½-inch tape width. This linear recording format has a *serpentine characteristic*. The drive mechanism makes multiple passes from the beginning of the tape to the end of the tape and back to read or write the full capacity of the cartridge. In the LTO Ultrium 6 format, the 2176 tracks are split into five bands of 544 tracks each. Table 2-1 shows the values for the Ultrium 6 and previous LTO generations.

Table 2-1 Data tracks, density, and channels

LTO generation	Data tracks	Tracks/band	Linear density	Read/write channels
Ultrium 1	384	96	124 kbpi	8
Ultrium 2	512	128	188 kbpi	8
Ultrium 3	704	176	250 kbpi	16
Ultrium 4	896	224	328 kbpi	16
Ultrium 5	1280	320	368 kbpi	16
Ultrium 6	2176	544	368 kbpi	16

Data is written to the innermost bands first to provide protection to the data that was recorded earliest in the process by writing it in the center, which is the most physically stable area on the tape. Data also is verified as it is written. On the first pass of a round trip down the length of the tape and back, 16 tracks (see the “Read/write channels” column in Table 2-1) at LTO Ultrium 6 format are concurrently read or written. At the end of the tape, the second pass of the round-trip starts. The read/write heads are indexed and positioned over 16 new tracks, and the tape reverses direction back toward the beginning of the tape to complete the round trip. For the next round trip, the heads again are indexed to a new position over a new group of 16 tracks.

Because track densities (as shown in Table 2-1) are high and because the tape is subject to lateral movement as it is moved, for performance and data integrity, the read/write heads must always be positioned precisely over the correct tracks. This positioning is accomplished by using the *timing-based servo* technique. This technique makes it possible to use high track densities (now and in the future) without changing the format of the media. This technique also provides the ability to read data, even with media imperfections.

In the LTO system, electronic signals are generated through the real-time reading of servo data bands that are pre-recorded on the LTO tape. These signals enable the servo system to dynamically control the positioning of the read/write heads across the width of the tape. Similar magnetically based, track-following servo systems are used successfully in tens of thousands of tape drives that are in use today, such as the IBM TotalStorage 3590 tape drive (IBM 3590) and IBM TotalStorage 3592 tape drive (IBM 3592).

The LTO formats also use advanced error correction codes for data integrity. These systems automatically correct most cross-track errors and provide data correction even if a full track is lost. Data is further protected by the demarcation of bad areas of the tape (for example, where servo signals are unreliable) and through dynamically rewriting bad blocks. Cartridge memory is embedded in the LTO cartridges to record use and error information. A noncontacting radio frequency module, with nonvolatile memory capacity of 16320 bytes for Ultrium 6, 8192 bytes for Ultrium 4 and Ultrium 5, and 4096 for LTO Ultrium 3, provides for storage and retrieval.

Ultrium tape formats

Figure 2-3 and Figure 2-4 show the IBM Ultrium cartridges, which are distinguished by color. The first-generation IBM Ultrium LTO cartridge is black, the second generation is purple, the third generation is slate-blue, the fourth generation is green, and the fifth generation is burgundy. The Ultrium 6 cartridge is colored black. The IBM Write Once Read Many (WORM) cartridges are two-tone cartridges with a platinum bottom. The top is like the normal LTO Ultrium cartridges. For the third generation of IBM WORM cartridges, the top is slate-blue; for the fourth generation, the top is green; and for the fifth generation, the top is burgundy. The Ultrium 6 WORM cartridge is colored black with a platinum bottom.

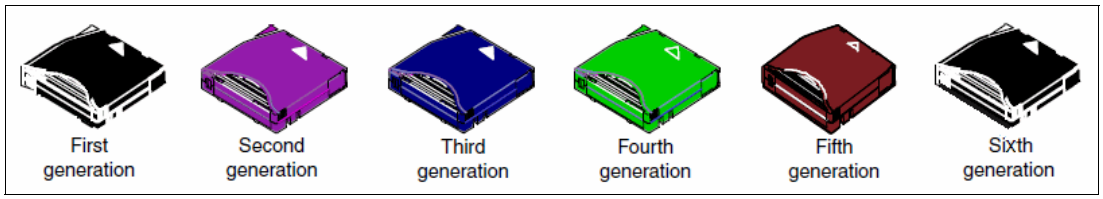


Figure 2-3 Generations of IBM LTO Ultrium tape cartridges



Figure 2-4 IBM LTO Ultrium 3 WORM tape cartridges

The Ultrium tape format specification is the implementation of LTO that is optimized for high capacity and performance with outstanding reliability, in a stand-alone or automated environment. The Ultrium cartridge uses a larger single-reel design (see Figure 2-3 on page 46 and Figure 2-4 on page 46) and ½-inch tape to provide ultra-high storage capacity. The tape is extracted from the cartridge by the tape drive through a leader pin and is wound onto a take-up reel that is contained within the drive. This design is focused on client requirements for high capacity and performance and is ideally suited for backup, restore, and archive applications. Ultrium drive technology is intended to meet the needs of the enterprise on a roadmap, or migration path, that extends well into the future. The Ultrium tape format established a new benchmark for large volume backup and archive options.

WORM tape format

Beginning with LTO Ultrium format generation 3, WORM functionality provides for nonerasable, nonrewritable operation with tape media and is for long-term, tamper-resistant record retention. LTO Ultrium 4, Ultrium 5, and Ultrium 6 drives provide the same WORM capability.

The format specification for WORM for LTO Ultrium generations includes low-level encoding in the cartridge memory and is mastered into the servo pattern as part of the manufacturing process. This encoding prevents tampering.

Data can be appended at the end of a WORM cartridge to which data was previously written, which allows the full use of the high-capacity tape media.

Interleaved recording

The LTO drive uses an interleaved, serpentine, longitudinal recording format. The first set of 8 or 16 data tracks is written from near the physical beginning of the tape to near the physical end of the tape. The head then repositions to the next set of tracks for the return. This process continues until all tracks are written and the tape is full.

The format of the recording of the data and servo tracks is defined as part of the LTO specification to meet the requirement for interchange among implementations of different manufacturers.

Servo tracks

Servo tracks or bands enable accurate positioning of the tape drive head over the data track, which ensures that the head does not stray onto an adjacent track. They are necessary to support high-data densities on the tape where the tracks are extremely close together. The servo bands are written when the cartridge is manufactured, before the cartridge is usable for data storage and retrieval. If the servo bands are erased, the tape becomes unusable.

2.1.3 Data compression

The LTO Consortium created a superior data compression technique known as LTO Data Compression (LTO-DC). Although an excellent data compression algorithm, adaptive lossless data compression (ALDC) is not optimized for incompressible data, such as encrypted or previously compressed data. For incompressible data, it is best not to apply any data compression algorithm, but rather to pass the input data directly to the compressed data stream (pass-through). Given the variations in data, there are times when ALDC is desirable and times when a simple pass-through is better. For example, if ALDC-based data compression is used, it is best if all segments of incompressible data are recorded without expansion by using a pass-through technique.

Figure 2-5 shows the LTO-DC data compression technique that uses the two schemes.

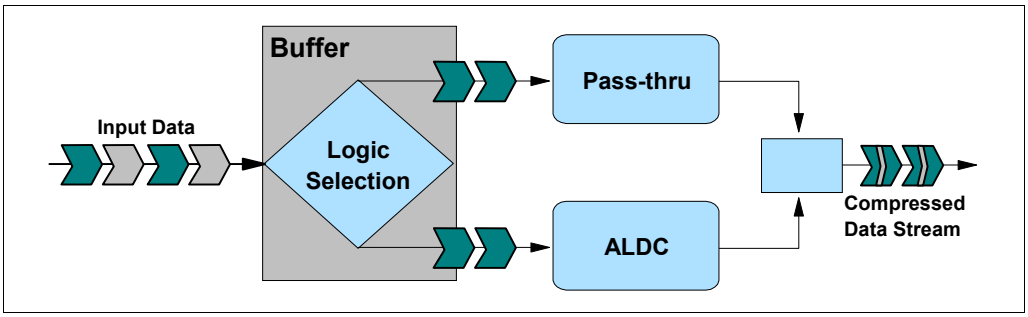


Figure 2-5 LTO-DC block diagram

The ability to swap schemes between ALDC and a pass-through mode gives a tape drive the power to automatically adapt to the incoming data stream.

No standardization of when to swap modes (scheme swap) when compressing data was specified by LTO-DC. LTO-DC was approved by Ecma International as the Streaming Lossless Data Compression (SLDC) standard. For more information, see this website:

`http://www.ecma-international.org/publications/standards/ECMA-321.htm`

Compression technique: LTO uses the SLDC technique for compression. The IBM 3592 tape drive also uses the SLDC compression technique.

Because no standardization is specified, all vendor implementations might perform scheme swapping differently. What is specified and tested is that the resultant compressed data stream is decompressible by the defined set of LTO-DC rules. This capability enables interchange between drives from multiple vendors. Each vendor's Ultrium drive can read and decompress the LTO-DC streams of the other vendors' Ultrium drives.

2.1.4 Tape cartridge

The Ultrium tape cartridge is a single-reel cartridge, meaning that the whole tape is wrapped around a single reel when the cartridge is not loaded in a drive. During the loading process, the threader of the drive catches the leader pin of the tape and threads it through the drive and the machine reel. During the read/write process, the tape is stored on the machine reel and the cartridge.

Figure 2-6 and Figure 2-7 show two views of the tape cartridge.

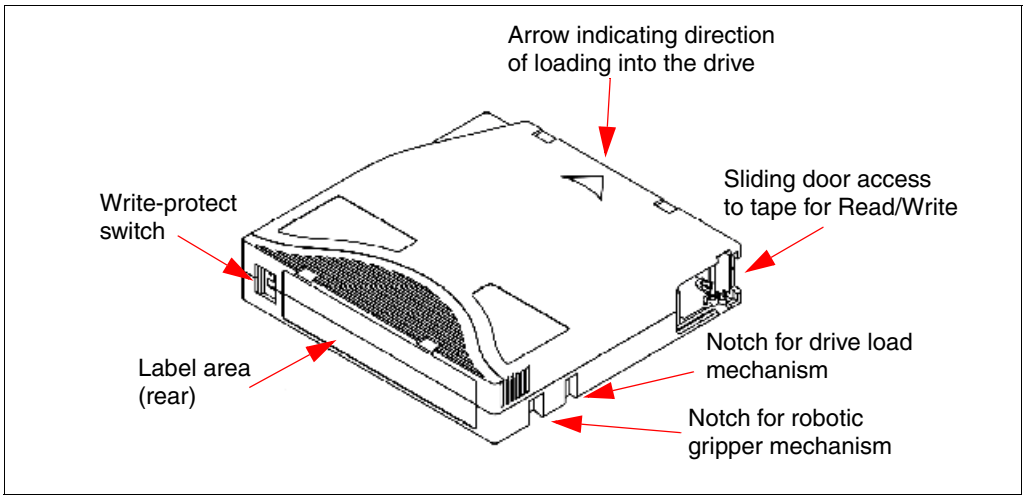


Figure 2-6 View of the Ultrium tape cartridge from the top and rear

The cartridge is approximately 10.2 cm long, 10.5 cm wide, and 2.2 cm high (which is approximately 4 x 4.16 x 0.87 inches). The cartridge contains 12.6 mm (½-inch) metal-particle tape with a high-density recording area.

Figure 2-7 shows several components of the cartridge.

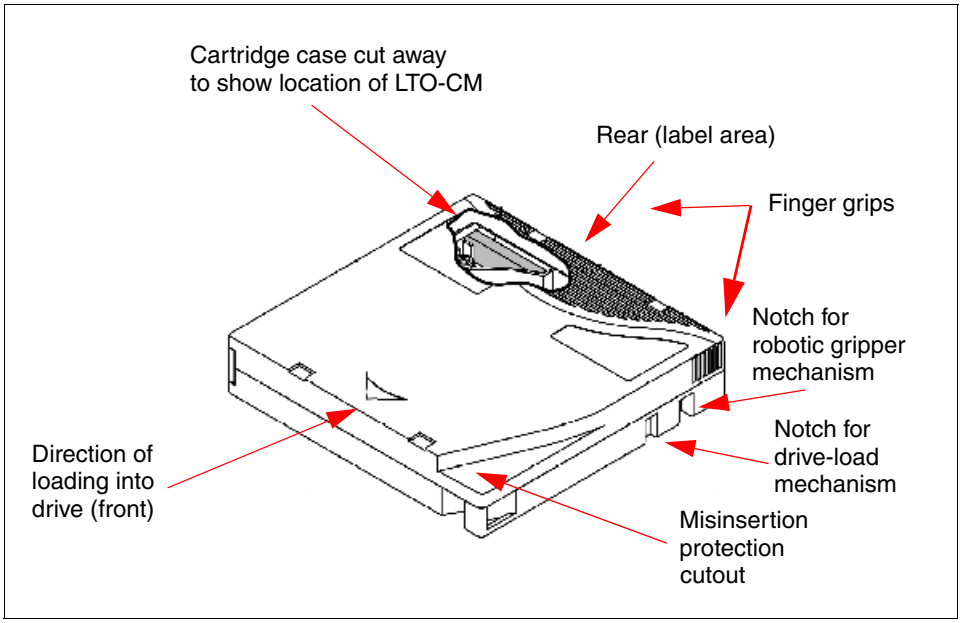


Figure 2-7 Ultrium cartridge view from top and front

The cartridge includes the following components:

- Grips

  Molded areas on the cartridge casing that are finger grips for manual loading.

- Label area

  At the designated area at the rear of the cartridge where the adhesive bar code label is applied.

- Sliding door

  Cartridge door (see Figure 2-6 on page 49) that protects the tape from contamination whenever the cartridge is out of the drive. Behind the door, the tape is threaded onto a leader pin (as shown in Figure 2-8), which is used to pull the tape from the cartridge for use. A locking mechanism prevents the media from unwinding when the cartridge is not in the drive.

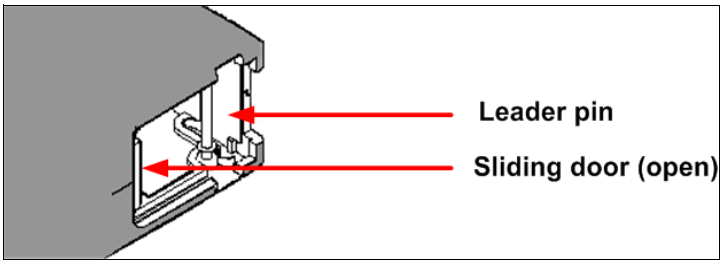


Figure 2-8 Leader pin attached to the tape medium

- Notches

  Two sets of molded notches in the cartridge casing are on the sides near the rear. The first pair enables the robotic gripper to pull the cartridge out of the drive mouth after the cartridge is unloaded. The second pair enables the drive to grip the cartridge and pull it into the loading position inside the drive.

- Misinsertion protection

  A cutout in the front side of the cartridge casing that prevents the cartridge from being inserted into the drive in the wrong orientation. This feature prevents the use of unsuitable cartridges of similar, but not identical, construction.

The various cartridges are color-coded for easy visual distinction, as shown in Table 2-2. (For more information, see “Ultrium tape formats” on page 46).

Table 2-2 Data cartridge identification by case color

Data cartridge	Case color
Ultrium 6 WORM	Black top, platinum (silver gray bottom)
Ultrium 5 WORM	Slate burgundy top, platinum (silver gray bottom)
Ultrium 4 WORM	Slate green top, platinum (silver gray bottom)
Ultrium 3 WORM	Slate blue top, platinum (silver gray bottom)
Ultrium 6	Black
Ultrium 5	Burgundy
Ultrium 4	Green
Ultrium 3	Slate blue
Ultrium 2	Purple
Ultrium 1	Black

Although the servo tracks are similar on Ultrium 1 and Ultrium 2 cartridges, Ultrium 2 cartridges are required with an Ultrium 2 drive to achieve Ultrium 2 capacity. Similarly, Ultrium 5 and Ultrium 6 cartridges are required to achieve Ultrium 5 and Ultrium 6 drive capacity. For more information about media compatibility among the generation, see 2.3.1, “IBM Ultrium 1, 2, 3, 4, 5, and 6 compatibility” on page 72.

LTO data cartridge capacity

When the Ultrium tape cartridge is processed, the Ultrium tape drive uses a linear, serpentine recording format. The Ultrium 4 drive reads and writes data on 896 tracks, and the Ultrium 5 drive writes data on 1280 tracks, also 16 tracks at a time. The Ultrium 6 drive reads and writes data on 2176 tracks, 16 tracks at a time. The first set of tracks is written from near the beginning of the tape to near the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until all tracks are written and the cartridge is full or until all data is written.

To ensure that the IBM Ultrium tape drive conforms to the IBM specifications for reliability, IBM suggests the use of only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium data cartridges cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

Table 2-3 lists the native data capacity of Ultrium data cartridges.

Table 2-3 Native capacity

Data cartridge	Native data capacity
Ultrium 6 WORM	2500 GB (6250 GB at a 2.5:1 compression ratio)
Ultrium 5 WORM	1500 GB (3000 GB at a 2:1 compression ratio)
Ultrium 4 WORM	800 GB (1600 GB at a 2:1 compression ratio)
Ultrium 3 WORM	400 GB (800 GB at a 2:1 compression ratio)
Ultrium 6	2500 GB (6250 GB at a 2.5:1 compression ratio)
Ultrium 5	1500 GB (3000 GB at a 2:1 compression ratio)
Ultrium 4	800 GB (1600 GB at a 2:1 compression ratio)
Ultrium 3	400 GB (800 GB at a 2:1 compression ratio)
Ultrium 2	200 GB (400 GB at a 2:1 compression ratio)
Ultrium 1	100 GB (200 GB at a 2:1 compression ratio)

Metal particle tape medium

The metal particle tape medium consists of a transparent polyethylene base material with two coatings. On one side, the base has two fine coats of a strong yet flexible ferromagnetic material, which is dispersed in a suitable binder. This side is the surface on which the data is written. The back surface is coated with a non-ferromagnetic conductive coating.

Metal particle media have high *coercivity*, which is a measure of their ability to retain their magnetic properties after the data is written to the tape. Coercivity is one of the factors in enabling a potentially longer shelf life than other media.

Cartridge memory

Within the cartridge is the LTO Cartridge Memory (LTO-CM), which is a passive, contactless silicon storage device that is physically a part of the cartridge. The memory chip also is known as medium auxiliary memory (MAM). For more information, see the *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference*, GA32-0928.

Information about the cartridge and tape is written to the LTO-CM. The LTO-CM is only accessible and used by the drive itself and contains no customer data. The LTO-CM is serial Electronically Erasable Programmable Read-Only Memory (EEPROM) with read-only and rewritable areas. It is housed inside the cartridge casing at the left rear (label side) corner as shown in Figure 2-7 on page 49.

The LTO-CM is used to hold use and error information about the cartridge, the media inside that cartridge, and the data on the media. The storage capacity of the Generation 6 LTO-CM is 16320 bytes, double the 8160 byte capacity of the Generation 5 and 4 LTO-CM. The Generations 1, 2, and 3 cartridges use a 4096 byte LTO-CM. The LTO-CM is in the left rear corner of the cartridge. A copy of this information also is kept in the first data set within the user data area and is given the data set number zero.

Communication between the drive and the LTO-CM is performed by a low-level radio frequency (RF) field generated (in the IBM implementation) by the drive. The LTO-CM is nonvolatile storage that is updated by using the RF field. It requires no other power source. This type of technology has an expected shelf life of more than 30 years.

Although transparent to the user, keeping this type of information enhances the efficiency of the drive and the cartridge. Data and block locations are stored in memory. For example, the end-of-data location is stored so that when the tape is next loaded, the drive can use the fast locate function to move directly to the recording area and begin recording. Storing data about the age of the cartridge, the number of times it was loaded, and the number of errors it has accumulated aids in determining the reliability of the cartridge. This data is of particular value if it is stored with the cartridge itself, so that whenever the cartridge is mounted on any host system, the history is accessible.

This product is not the first tape product where information was kept on the cartridge. However, previously it was written on the tape medium itself in a portion of the tape not accessible to users, before the beginning-of-tape marker, such as in the IBM 3590 tape drive.

Bar code label

Each data and cleaning cartridge that is processed by an Ultrium tape library must have a bar code label. This bar code label is mandatory for libraries that have an installed bar code reader. The label, as shown in Figure 2-9, contains a human-readable volume serial number or volume label and the corresponding machine-readable bar code.

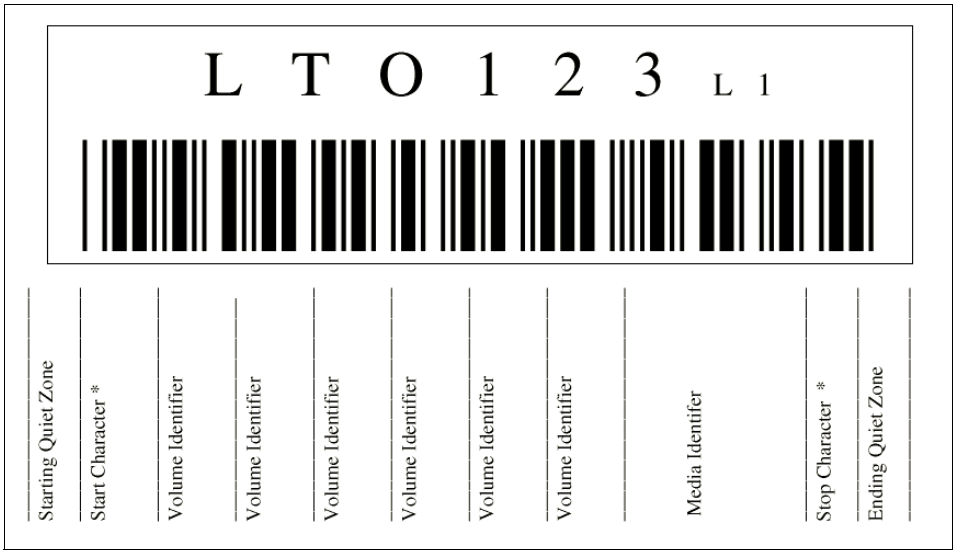


Figure 2-9 Bar code label example

The bar code has the following format:

- Quiet zones at each end of the bar code
- A start character indicating the beginning of the label
- A six-character volume label
- A two-character cartridge media-type identifier (L1, L2, L3, L4, L5, or L6) that identifies the cartridge as an LTO cartridge (“L”) and indicates the LTO generation of 1, 2, 3, 4, 5, or 6

  Other identifiers also are specified by the LTO standard. Therefore, the LTO-3 WORM cartridge is identified by LT, the LTO-4 WORM cartridge is identified by LU, the LTO-5 WORM cartridge is identified by LV, and the LTO-6 WORM cartridge is identified by LW.
- A stop character indicating the end of the label

When read by the bar code reader of the library, the bar code identifies the volume label of the cartridge to the tape library. The bar code volume label also indicates to the library whether the cartridge is a data, cleaning, or diagnostic cartridge.

Tape cartridges are often supplied with the labels already attached, or labels can be attached after purchase. The Ultrium cartridge features a recessed area for the label (see Figure 2-6 on page 49). The label must be applied only in the recessed label area. If the label extends outside of the recessed label area, it can cause loading problems in the drive.

Volume label format

The LTO cartridge label uses the Uniform Symbol Specification-39 bar code symbols.

The volume label of a cartridge consists of six characters, starting from the left. Except for cleaning and diagnostic cartridges, these six characters are limited to the following ASCII characters:

- Uppercase A - Z (ASCII character code: 41h - 5Ah)
- 0 - 9 (ASCII character code: 30h–39h)

The volume label must consist of six, all uppercase alphabetic, all numeric, or alphanumeric characters, such as ABCGVE, 123621, or F8H5N9. The volume label cannot consist of fewer than six characters.

A volume label format of CLN*Unn* represents a universal cleaning cartridge. A volume label of the form CLN*vnn* is used for a unique cleaning cartridge, where *v* is an alphanumeric identifier that represents the vendor of a drive-unique cleaning cartridge. (An IBM-unique cleaner cartridge uses the label format CLN*Inn*.) This identifier is logged in the vendor information pages in the Ultrium tape drive.

A volume label of the form DG(space)*vnn* is used for diagnostic and service cartridges. The drive uses the *v* to determine whether the drive-unique diagnostic cartridge is loaded. The *nn* represents a specific cartridge and is logged in the vendor information pages in the Ultrium tape drive.

The internal and external labels on a cartridge do not need to match. Therefore, the volume label on the bar code label does not need to match the volume label recorded on the tape in the tape label area when it is initialized. However, it is preferable for them to match to avoid confusion.

For more information, see the IBM LTO Ultrium Cartridge Label Specification section of this website:

http://www.ibm.com/systems/storage/media/lto/

Ordering bar code labels

For more information about ordering bar code labels, see Appendix B, “IBM LTO Ultrium and 3592 media” on page 449.

Write-protect switch

The write-protect switch is at the front of the cartridge to the left of the bar code label (see Figure 2-6 on page 49). The position of the write-protect switch on the tape cartridge determines whether the tape can be written to. The tape cannot be written to when the switch is pushed to the right. When the write-protect switch is set to inhibit writing, a visual lock mark (such as a padlock) is visible.

In most cases, back up and recovery host application software is used to achieve the most benefit from the use of an LTO system. It is better to rely on the host application software to write-protect the cartridges rather than to manually set the write-protect switch. This way, the host software can identify a cartridge that no longer contains current data and is eligible to become a scratch cartridge. If the switch is set and the host application sets the cartridge to scratch status, the tape drive is unable to write new data to the tape.

Cartridge life

The magnetic tape inside the cartridge is made of highly durable materials. However, the tape wears after repeated cycles. Eventually, such wear can cause an increase in tape errors, records of which are stored in the LTO-CM. Cartridge performance can be tracked and monitored, which enables predictive failure analysis and enhances data integrity. This tracking is done automatically, and the drive issues a message when errors on the tape exceed a threshold.

The IBM Ultrium 3, 4, 5, and 6 data cartridges have a usable life of 20,000 load and unload cycles in a typical office computer environment. Ultrium 1 and Ultrium 2 data cartridges have a usable life of 10,000 load and unload cycles. The data that is recorded on the cartridge has an archive storage life of a minimum of 30 years with less than 5% loss in demagnetization. The cartridge must be stored at 16° C (60° F) to 25° C (77° F), with 20–50% non-condensing humidity, and a wet bulb temperature of 26° C (79° F) maximum.

Specifications for cleaning cartridges

In the past, to support client and application requirements and expectations for cleaning, each LTO drive vendor provided its own cleaning cartridge specifically for its Ultrium drives. To avoid potential interoperability problems, the LTO consortium decided to introduce a universal cleaning cartridge. IBM only offers the universal cleaning cartridge type, and this can be used on any LTO drive type.

The IBM Ultrium LTO tape drive is self-monitoring and self-cleaning. Therefore, use the automatic cleaning function that is provided with the library or by the application as recommended by IBM. Each drive determines when it must be cleaned and alerts the library or the application to initiate a cleaning cycle.

To prevent recontamination of drive surfaces, each specific cleaner cartridge is limited up to 50 cleaning cycles. Cleaner tape use is determined by the length of the tape already used, and so the average number of cleaning cycles for a cleaning cartridge is 50, but it may be marked used before, or after, 50 mounts.

2.1.5 IBM LTO Ultrium common subassembly drive

Certain elements of the Ultrium drive design are covered by the LTO format specification, such as anything related to writing the specified data format that enables tape interchange. However, there is no strict LTO definition in terms of how the drive module is constructed. Therefore, in this area, manufacturer drives might differ from each other in performance and specification, such as the data rate or quality design points.

This section relates specifically to the IBM LTO implementation. However, it emphasizes again that the IBM LTO Ultrium cartridges are compatible with those of all other licensed manufacturers.

The IBM LTO Ultrium common subassembly drive (as shown in Figure 2-10) is a high-performance, high-capacity tape drive. The drive records data by using the specified linear serpentine recording format on ½-inch tape that is housed within the LTO Ultrium cartridge. The data tracks are located by using preformatted servo tracks, as described in “Servo tracks” on page 47.



Figure 2-10 IBM LTO Ultrium common subassembly

The original basic unit was the first-generation IBM LTO series of products. Subsequent generations of IBM LTO promote extensive reuse, making the IBM Ultrium drives extremely reliable. Especially starting in LTO-3, several reliability improvements were made to tape path and internal tape handling. These units are a common subassembly and, therefore, do not have an IBM machine type. The subassembly is not available for clients to purchase directly, but only as a part number that is used in the assembly of other IBM machine types. The subassembly does not have its own power supply, but is powered by the library, frame, or casing into which it is integrated.

The IBM machine types that integrate the subassembly are addressed in 2.6.2, “The IBM LTO Ultrium family of tape drives and libraries” on page 99, and in later chapters. The subassembly is sold on the other equipment manufacture (OEM) market to other LTO library manufacturers. The common subassembly is a single field-replaceable unit (FRU). That is, if it fails, the whole unit is replaced, and no parts or subassemblies within the unit are replaced when the drive is maintained by an IBM service support representative (SSR).

Drive head

When the cartridge is inserted into the drive, a threading mechanism pulls the leader pin and attached tape (see Figure 2-8 on page 50) out of the cartridge, across the drive read/write head, and onto a nonremovable take-up reel. The drive head can then read or write data from or to the tape.

In generations 1 and 2, the drive has a 2 x 8 element head, reading or writing data eight tracks at a time, as shown in Figure 2-11 on page 57. Unlike the IBM 3590, for example, it does not cover the whole width of the tape.

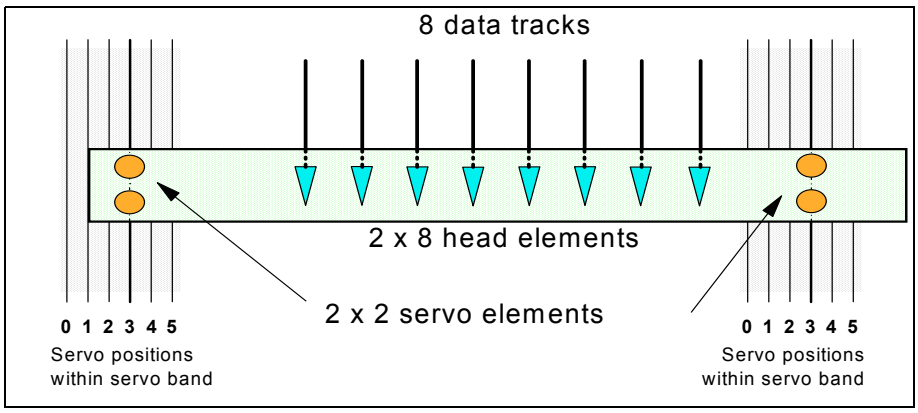


Figure 2-11 Generation 1 and 2: One of eight element heads shown, with servo elements

The write elements are immediately followed by read/verify elements. Therefore, two sets of eight head elements (eight write elements and eight read elements) allow the tape to write in the forward and reverse directions down the length of the tape. Two sets of heads (read/write and write/read) are required because the tape is written and read in both directions.

The LTO Generation 3, LTO Generation 4, LTO Generation 5, and Generation 6 drives have a 2 x 16 element head, reading or writing data at 16 tracks at a time. Conceptually, they are similar to the 8 element head, except that they have elements of a smaller size.

Figure 2-12 shows the allocation of read and write heads for forward and reverse wraps.

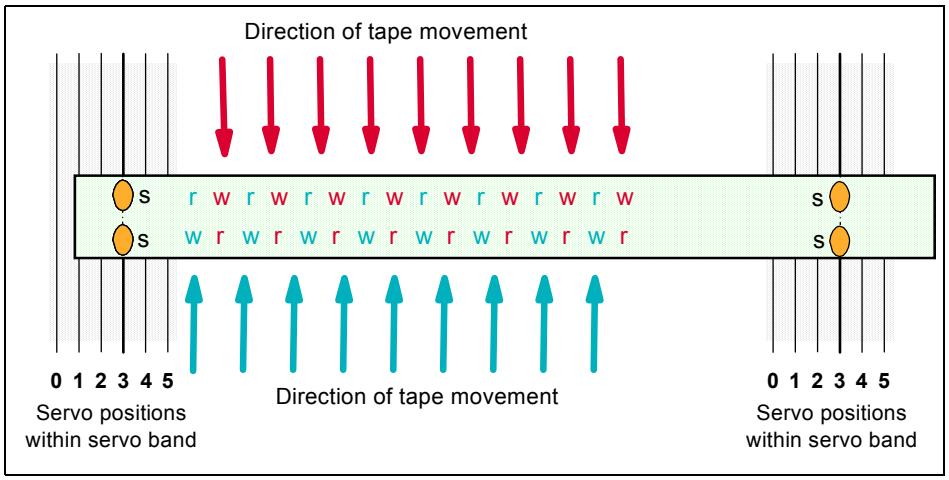


Figure 2-12 Conceptual allocation of read and write heads for forward and reverse wrap

Four servo elements are used: two for each set of read/write elements. The head uses both servo tracks at each edge of the data band it writes.

For more information, an animated conceptual explanation can be found in the LTO Ultrium technology primers at this website:

`http://www.lto.org/technology/what-is-lto-technology/`

The animation on the website provides a basic understanding of LTO technology.

Data compression

As described in 2.1.3, “Data compression” on page 47, data compression implementation can differ from vendor to vendor. However, all vendors conform to the basic rules, and the data that is written by one vendor’s drive can be read by the drives of any other vendor.

The LTO consortium decided, as many other vendors also do in the open environment, to indicate characteristics of LTO products for both native data and when assuming a data compression ratio of 2:1. For enterprise-related (mainframe) tape products, IBM and other manufacturers assume a compression ratio of 3:1, even though the IBM LTO and IBM 3592 use the same compression algorithm (SLDC). In any case, the real compression that is reached by the drive depends on the nature of the data. Any capacity sizing estimates should be based on the native value.

Interfaces

The IBM LTO Ultrium drive is available with a choice of the following interfaces:

- SCSI:
  - Low Voltage Differential (LVD)
  - High Voltage Differential (HVD; LTO-1 and 2 only)
- Serial-Attached SCSI (SAS)
- Fibre Channel (FC)
- Universal Serial Bus (USB)

When an IBM tape drive product is ordered, a drive interface is chosen. The interface cannot be changed after it is ordered. If a different interface is required, the complete drive assembly must be replaced.

Historically, SCSI connections were used for attachment of tape drives and libraries to open systems. Fibre Channel connections using SANs have become standard technology. SAS connections are now the SCSI standard. SCSI LVD options were still available on the Ultrium 4 Full-High drives when this was written. USB 3.0 connectivity is now available on TS2250 and TS2260.

Important: IBM LTO Ultrium 5 and Ultrium 6 tape drives have only FC, SAS or USB connectivity options.

SCSI single ended

SCSI single ended was the most common form of SCSI signaling. Many removable drives, scanners, and almost all 50-pin SCSI devices fit into this category. Often “single-ended” or “SE” is not written on the documentation. If a device does not specifically indicate LVD, Ultra2 Wide, differential, or a similar definition, it is probably single ended. Typically, single-ended devices support a total bus length of 1.5 meters (5 ft.) or less.

IBM high-performance SCSI tape drives (IBM 3590, IBM 3570, and LTO Ultrium drives) are all differential-attached drives, not single-ended drives.

SCSI differential (HVD)

HVD (often referred to as just *differential*) uses differential signaling. The idea behind differential signals is that each bus signal is carried on a pair of wires. The first wire of the pair carries the same type of signal as a single-ended SCSI. However, the second wire of the pair carries its logical inversion. The receiver of the signals takes the difference of the pair (therefore, the name), which makes it less susceptible to noise and capable of supporting greater cable lengths. HVD and single-ended SCSI are incompatible with each other.

In general, IBM HVD tape devices support an overall bus length of 25 m (82 ft.) that use point-to-point or multidrop interconnection (*daisy chaining*). For each daisy-chain device, the maximum cable length must be reduced by 0.5 m (1.6 ft.).

SCSI differential

The newer SCSI differential interface implementation, LVD, uses less power than the HVD differential interface and allows the higher speeds of Ultra2 SCSI. LVD requires 3.3 V dc instead of 5V dc for HVD.

LVD is sometimes referred to as *Ultra2 Wide SCSI*, which is a general marketing term for 16-bit Fast-40 or 80 MBps. Only LVD and HVD can run in Ultra2 Wide mode and only LVD in current commercially available products.

IBM LVD tape devices support a bus length of 25 m (82 ft.) point-to-point and 12 m (39.4 ft.) by using multidrop interconnection (daisy chaining). For each daisy-chain device, the maximum cable length must be reduced by 0.5 m (1.6 ft.).

The terms *fast*, *wide*, and *ultra* indicate characteristics that are separate from those characteristics implied by differential, single-ended, and high or low voltage. Table 2-4 shows the SCSI terms that are used to describe different host and device adapters and what they imply with regard to bus width and speed.

Table 2-4 SCSI terms and characteristics

SCSI term	Bus width (bits)	Speed (MBps)	Maximum length	Maximum number of devices
SCSI	8	5	6 m	7
Fast SCSI	8	10	3 m	7
Fast Wide SCSI	16	20	3 m	15
Ultra (Wide) SCSI HVD	16	40	25 m	15
Ultra (Wide) SCSI 2 LVD	16	80	25 m/12 m	15
Ultra 160 SCSI LVD	16	160	12 m	15

A faster bus does not imply that an attached device supports that data rate, but that multiple devices can operate on the bus at that maximum speed. For more information about SCSI terms and related specifications, see the SCSI Terms and Terminology Table from the SCSI Trade Association at this website:

http://www.scsita.org/terms-and-terminology.html

To ensure best performance, avoid daisy chaining if possible.

Serial-attached SCSI history

Serial-attached SCSI (SAS) was introduced because parallel SCSI has a maximum bandwidth of 320 MBps. There was a need for a faster interface to attach tapes and disks on a host bus adapter (HBA). In 1981, Adaptec designed a standardized bus that became ANSI approved. From that time forward, it was called Small Computer System Interface (SCSI).

SCSI attaches hard disks on an I/O bus. However, over the years, all types of devices were able to connect to the SCSI bus, such as tape drives, scanners, plotters, printers, and optical devices. As the types of devices changed, the bandwidth increased from 5 MBps up to 320 MBps, better known as Ultra320 SCSI.

In 2003, the SCSI bus speed was increased up to 640 MBps, but it never became a standard for the SCSI speed. One problem when the SCSI speed increases is a phenomenon called *clock skew*. Clock skew occurs in synchronous circuits in which the clock signal that is sent from the clock circuit arrives at different components at different times. This action is typically the result of two causes. The first cause is material variability, in which a signal travels faster or slower than expected. The second cause is distance. The further a signal must travel, the longer it takes to arrive. Therefore, signals arrive at different points at different times. As the clock rate of a circuit increases, timing becomes more critical, and less variation can be tolerated while still functioning properly.

The industry was looking for a new, faster interface. A serial version of SCSI was designed and approved in 2002 by the SCSI Trade Association and by the International Committee for Information Technology Standards. In 2005, the first devices came on the market with a SAS interface. The first generation of SAS has a native speed of 3 Gbps and the current generation of SAS is 6 Gbps. Figure 2-13 shows future generations on the SAS roadmap.

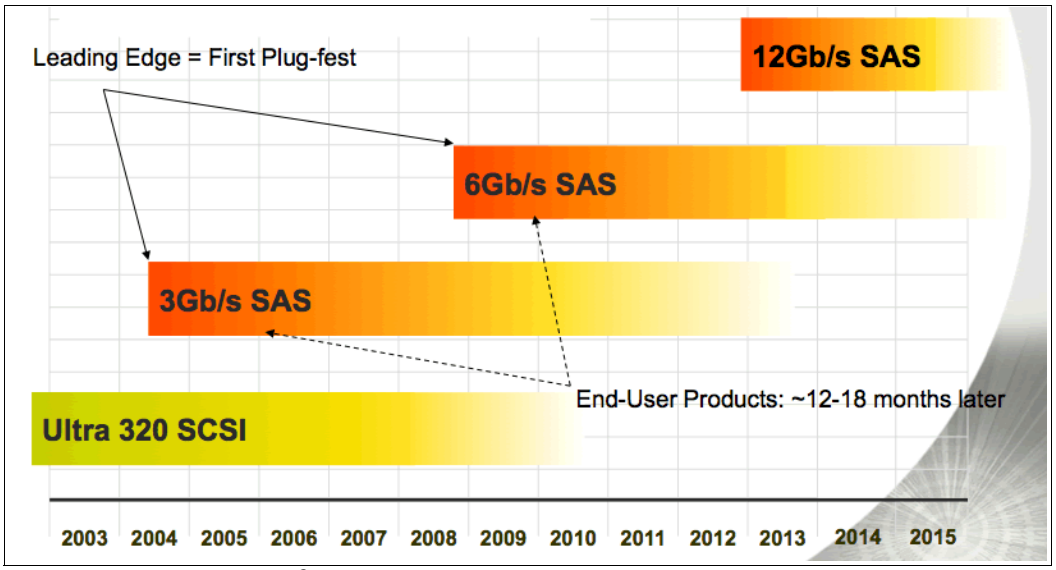


Figure 2-13 SAS roadmap[2]

A benefit of SAS is that it can communicate with *Advanced Technology Attachment* (ATA) devices. SAS has a point-to-point architecture and a bandwidth of 300 MBps. Because of its point-to-point architecture, more devices can be handled at the same time on the bus with a maximum of 128 targets. Another advantage of SAS is that the connection cables between the HBA and the devices are much thinner and more scalable. SAS devices do not need external terminators. The I/O bus is electronically terminated.

The total cable length from the device to the HBA is limited to 5.5 m (18.04 ft.). The total cable length in an LVD configuration is 25 m (82 ft.) when a point-to-point connection is used or 12.5 m (39 ft.) when a multidrop connection is used.

[2] Roadmap is published by SCSI Trade Association, which is available at this website: http://www.scsita.org/library/2011/06/serial-attached-scsi-master-roadmap.html

Figure 2-14 shows an IBM 6 Gbps SAS adapter, part number 46M0907.

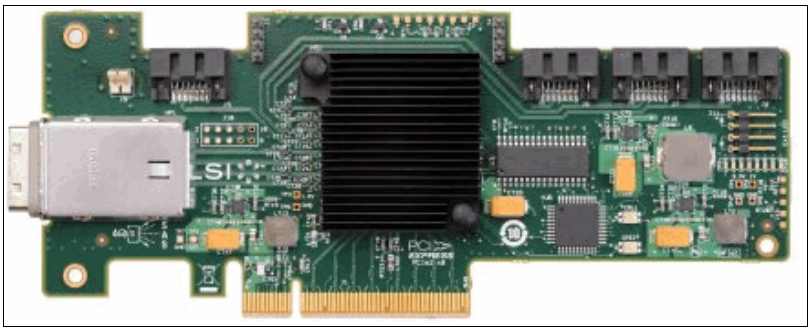


Figure 2-14 SAS HBA with IBM part number 46M0907

The Peripheral Component Interconnect Express (PCIe), small form-factor IBM 6 Gb SAS HBA, is based on LSI's SAS2008 controller and can handle medium- to large-capacity server storage applications by connecting an 8-lane PCIe adapter with one external x4 SFF-8088 connector and four internal SATA connectors.

The following connecting interfaces are used for connecting the external devices:

- *Mini-SAS* (SFF-8088), as shown in Figure 2-15.

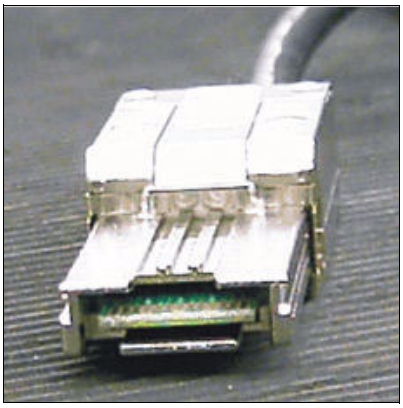


Figure 2-15 Mini-SAS (SFF-8088) connector

- SFF-8470, as shown in Figure 2-16.



Figure 2-16 SAS (SFF-8470) connector

All IBM SAS tape drives have a *Mini-SAS* (SFF-8088) interface. SAS cables are available in several lengths with a maximum length of 5.5 m (18.04 ft.) and in any combination of the SFF-8470 and SFF-8088 connectors.

The requirements for SAS bus connections are different for the SCSI bus. Each tape drive is required to have a dedicated bus to the initiator, referred to as point-to-point connection. SAS architecture does not support multiple tape drives that are connected to a single host adapter port. The following IBM LTO tape drives are available with the SAS interface:

- IBM LTO Ultrium 4 Full-High and Half-High tape drive
- IBM LTO Ultrium 5 Full-High and Half-High tape drive
- IBM LTO Ultrium 6 Full-High and Half-High tape drive

SCSI Connector types

When cables are ordered, careful attention should be paid to the type of connector on the cable and device so that everything connects correctly. This section describes the SCSI major connector types.

SCSI HD68

The HD68 connector (as shown in Figure 2-17) is the normal 68-pin SCSI connector. All IBM LTO SCSI drives (except the drives in the 3584) have an HD68 connector. Before 12 June 2001, all LTO tape drives in the IBM 3584 used HD68 connectors.

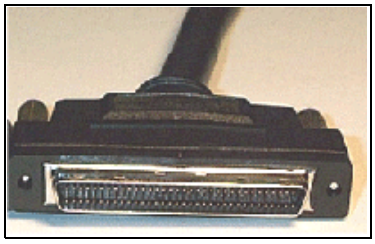


Figure 2-17 HD68 connector

SCSI VHDCI

The very high-density connector (VHDCI) is a mini-SCSI connector (as shown in Figure 2-18), about half the width of the HD68 connector. The IBM LTO drives in the IBM 3584 have a VHDCI connector.

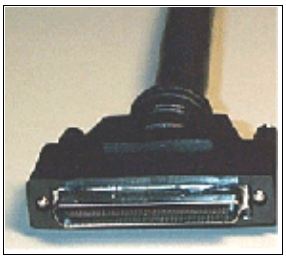


Figure 2-18 VHDCI connector

Fibre Channel

One of the biggest challenges with SCSI tape technologies is the limited ability to share storage devices between systems. Fibre Channel (FC) storage area networks (SANs) enable greater connectivity of servers to storage devices including tape drives. It becomes possible to share devices easily between systems by Fibre Channel attaching them to SAN switches, which allows any servers that are attached to that SAN fabric and have the correct SAN zoning to access to the devices. The latest FC devices are 8 Gbps capable, where older devices attach at 4 Gbps, 2 Gbps, or 1 Gbps. FC devices auto-negotiate speeds with switches to find the highest compatible speed.

The following IBM LTO tape drives are available with the FC interface:

- IBM LTO Ultrium 4 Full-High and Half-High tape drive
- IBM LTO Ultrium 5 Full-High and Half-High tape drive
- IBM LTO Ultrium 6 Full-High and Half-High tape drive

The maximum distances that a drive or library supports on a Fibre Channel link are determined by the link speed and the device to which the drive or library is attached.

If the library attaches to a server HBA, the distances that are supported by that HBA should be referred to. If the library attaches to a switch, the distances that are shown in Table 2-5 are supported.

Table 2-5 50 micron cabling distances

Data rate/Link speed	M5 (OM2) cable	M5E (OM3) cable	M5F (OM4) cable
8 Gbps	50 m (164 ft.)	150 m (492 ft.)	190 m (623 ft.)
4 Gbps	150 m (492 ft.)	380 m (1 247 ft.)	400 m (1312 ft.)
2 Gbps	300 m (984 ft.)	Not specified	Not specified
1 Gbps	500 m (1640 ft.)	Not specified	Not specified

FC Connector types

This section describes the following FC connector types:

- FC SC
- FC LC

FC SC

The duplex Subscriber Connector (SC) connector (as shown in Figure 2-19) is a low-loss, push/pull fitting connector. Each of the two fibers has its own part of the connector. The connector is keyed to ensure correct polarization (transmit to receive and receive to transmit) when connected. Most 1 Gbps SAN devices, including IBM Ultrium 1 FC drives, use SC connectors.

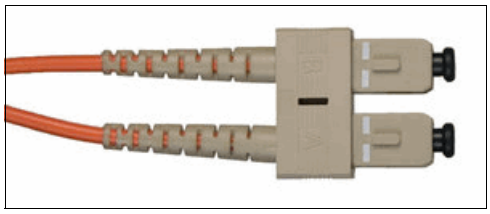


Figure 2-19 SC Connector

FC LC

Connectors that plug into SFF or small form-factor pluggable (SFP) devices are called *LC connectors*, as shown in Figure 2-20. Also, a duplex version is used so that the transmit and receive are connected in one step. The primary advantage of these LC connectors compared to SC connectors is that the LC connectors use a smaller form factor. Therefore, manufacturers of Fibre Channel components can provide more connections in the same amount of space.

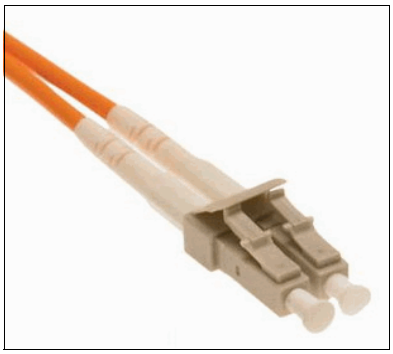


Figure 2-20 LC connector

Most 2 Gbps or higher SAN devices, including the IBM Ultrium 2, 3, 4, 5, and 6 FC drives, use LC connectors.

Universal Serial Bus (USB)

Universal Serial Bus (USB) has been around since the early 1990 and was designed as a standard to connect various input/output (I/O) devices to a personal computer. The first standard was USB 1, which was low speed at a maximum rate of 12 Mbps. USB 2 was introduced and improved the maximum speed to 280 Mbps, which allowed it to be used to connect external storage devices for data backup purposes.

USB 3.0 (also known as *SuperSpeed* USB) was released in 2008 and improved the speed to a maximum bandwidth rate of 5 Gbps (gigabits per second). That translates to 640 MBps (megabytes per second). This allows the connection to high-speed devices, such as LTO tape drives. IBM has introduced two tape drive models, the TS2250 and TS2260, both with the capability to connect by using a USB 3.0 Type B interface.

A USB 3 connector is identified by the color of the connection, which is blue. Figure 2-21 shows the common USB type A and B connectors.

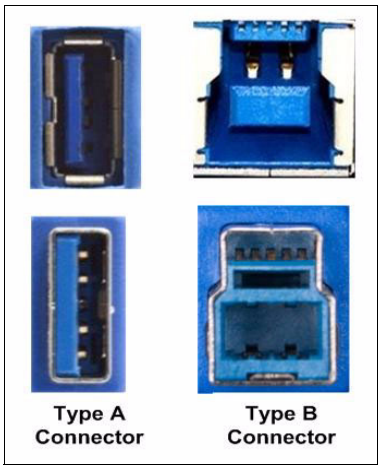


Figure 2-21 USB 3 connectors

Available interfaces for IBM Ultrium 1 tape drives

IBM Ultrium 1 drives offer the following connection types:

- Ultra2 Wide LVD SCSI that uses an HD68 connector
- Ultra Wide HVD SCSI that uses an HD68 connector
- FC-AL, 1 Gbps that use SC connector (3584 installed drives only)
- SCSI drives that are installed in the 3584 using a VHDCI connector

Available interfaces for IBM Ultrium 2 tape drives

IBM Ultrium 2 drives offer the following connection types:

- Ultra 160 LVD SCSI that uses an HD68 connector
- Ultra Wide HVD SCSI that uses an HD68 connector
- Switched FC 2 Gbps that use an LC connector
- SCSI drives that are installed in the TS3500 tape library using VHDCI connectors

The FC drive can work in fabric or FC-AL mode. According to the SNIA standard, the drive first attempts to connect as a FC_AL. If this approach fails, the drive tries to log on as a fabric device. It automatically senses the speed and connects with 1 Gbps or 2 Gbps.

With the IBM 3584, the FC port speed and the FC protocol mode can be set.

Available interfaces for IBM Ultrium 3 tape drives

IBM Ultrium 3 drives offer the following connection types:

- Ultra 160 LVD SCSI that uses HD68 connector
- 3 Gbps SAS
- 6 Gbps dual SAS on version 2 (V2) Half-High models
- Switched FC 2 or 4 Gbps that use LC connector
- SCSI drives installed in the 3584 use the VHDCI connector

The FC drive can work in fabric or FC-AL mode. According to the SNIA standard, the drive first attempts to connect as FC_AL. If this approach fails, the drive tries to log in as a fabric device. It automatically senses the speed and connects with 1 Gbps, 2 Gbps, or 4 Gbps.

With the IBM 3584, the FC port speed and the FC protocol mode can be set.

Available interfaces for IBM Ultrium 4 tape drives

IBM Ultrium 4 drives offer the following connection types:

- Ultra 160 SCSI LVD that uses HD68 connector
- 3 Gbps dual port SAS
- 6 Gbps dual SAS on version 2 (V2) Half-High models
- 4 Gbps native FC
- 8 Gbps FC that uses LC connector on version 2 (V2) Half-High models

The FC drive can work in fabric or FC-AL mode. According to the SNIA standard, the drive first attempts to connect as FC_AL. If this approach fails, the drive tries to log in as a fabric device. It automatically senses the speed and connects with 1 Gbps, 2 Gbps, 4 Gbps, or 8 Gbps (V2).

With the IBM 3584, the FC port speed and the FC protocol mode can be set.

Available interfaces for IBM Ultrium 5 tape drives

IBM Ultrium 5 drives offer the following connection types on Full-High and Half-High models:

- 6 Gbps dual port SAS
- 8 Gbps native FC
- USB 3.0

With the USB option the drive has a single SAS port and a single USB port host interface. The USB host interface supports USB 3.0 connectivity and can negotiate a transfer rate. It also supports USB 2.0 connectivity at the slower transfer rates. The USB interface auto-negotiates speed.

There are no configurable topologies, thus no feature switches associated with USB. The tape drive with SAS/USB ports requires a device driver for USB 3.0 operation.

The FC drive can work in fabric or FC-AL mode. According to the SNIA standard, the drive first attempts to connect as FC_AL. If this approach fails, the drive tries to log in as a fabric device. It automatically senses the speed and connects with 1 Gbps, 2 Gbps, 4 Gbps, or 8 Gbps.

With the IBM 3584, the FC port speed and the FC protocol mode can be set.

Available interfaces for IBM Ultrium 6 tape drives

IBM Ultrium 6 drives offer the following connection types on Full-High and Half-High models:

- 6 Gbps dual port SAS
- 8 Gbps native FC
- USB 3.0

With the USB option the drive has a single SAS port and a single USB port host interface. The USB host interface supports USB 3.0 connectivity and can negotiate a transfer rate. It also supports USB 2.0 connectivity at the slower transfer rates. The USB interface auto-negotiates speed.

There are no configurable topologies, thus no feature switches associated with USB. The tape drive with SAS/USB ports requires a device driver for USB 3.0 operation.

The FC drive can work in fabric or FC-AL mode. According to the SNIA standard, the drive first attempts to connect as FC_AL. If this approach fails, the drive tries to log in as a fabric device. It automatically senses the speed and connects with 1 Gbps, 2 Gbps, 4 Gbps, or 8 Gbps.

With the IBM 3584, the FC port speed and the FC protocol mode can be set.

IBM Ultrium drives can be connected to many different types of servers. For more information about the server interface cards or Host-Bus-Adapters (HBAs) that are supported with the IBM Ultrium drives, see this website:

http://www.ibm.com/systems/support/storage/ssic

Important: When Fibre tape drives are connected to a Fibre HBA on the host server, make sure the Fibre Channel Tape Support option is enabled on the Fibre HBA so that proper class 3 error recovery is performed on the Fibre Channel. For more information about how to set this option, see the HBA manufacturer.

2.2 Tape encryption overview

Data is one of the most highly valued resources in a competitive business environment. Protecting this data, controlling access to it, and verifying its authenticity while maintaining its availability are priorities in this security-conscious world. Tape encryption is a process that answers many of these needs.

Beginning with Ultrium 4 and TS1120 (3592-E05) cartridge drives, the encryption of data on tape became possible.

The IBM TS1120 (3592-E05), TS1130 (3592 E06), TS1140 (3592 E07), TS1150 (3592 E08), Ultrium 4 drives, including the TS1040 (3588 F4A), Ultrium 5 drives including the TS1050 (3588 F5A), the TS1060 (3588 F6A) tape drives, can encrypt data as it is written to tape.

The TS1120, TS1130, TS1140, and TS1150 support multiple types of IBM TotalStorage Enterprise 3592 tape cartridge, including WORM cartridges.

The Ultrium 4 drives support IBM Ultrium 4 data cartridges for encryption, the Ultrium 5 drives support Ultrium 5 media, and the Ultrium 6 drives support Ultrium 5 or Ultrium 6 data cartridges for data encryption, including WORM cartridges. Encryption is performed at full line speed in the tape drive after compression.

Note: Compression before encryption is more efficient, as compressing encrypted data can affect the compression ratio. It is recommended not to mix software encryption with hardware compression or hardware encryption with software compression.

Important: The encryption process is less than 1% of the performance impact on the read/write throughput.

Encryption for the TS1120, TS1130, TS1140, and TS1150 tape drives is available at no charge. These drives can be installed in the TS3500 tape libraries.

For the Ultrium 4, Ultrium 5, and Ultrium 6 tape drives, the application-managed encryption method is available at no charge. The stand-alone tape drives include this application-managed encryption offering.

However, for those drives that are installed in libraries, system-managed and library-managed encryption requires a billable feature code (FC5901 for TS2900, FC1604 for TS3500, FC5900 for all other libraries) to be installed to support transparent LTO encryption. IBM Security Key Lifecycle Manager also is required in this case.

Supported tape libraries for different drives are shown in Table 2-6.

Table 2-6 Drive encryption support

Drive	TS2900	TS3100	TS3200	TS3310	TS3500	TS4500
LTO4	Yes	Yes	Yes	Yes	Yes	N/A
LTO5	Yes	Yes	Yes	Yes	Yes	Yes
LTO6	Yes	Yes	Yes	Yes	Yes	Yes
TS1120 encryption-capable drive	N/A	N/A	N/A	N/A	Yes	N/A
TS1130	N/A	N/A	N/A	N/A	Yes	N/A

Drive	TS2900	TS3100	TS3200	TS3310	TS3500	TS4500
TS1140	N/A	N/A	N/A	N/A	Yes	Yes
TS1150	N/A	N/A	N/A	N/A	Yes	Yes

Encryption adds significant strength to the security of the stored data without the processing overhead and the performance degradation that is associated with encryption that is performed on the server or the expense of a dedicated appliance.

Important: TS1120 tape drives that were produced before 8 September 2006, do not have the encryption capability. However, a chargeable upgrade is available (FC5592) to upgrade the TS1120. This encryption capability includes drive hardware and microcode additions and changes.

Encryption keys are used to encrypt data when it is written and to decrypt the data when it is read from a data cartridge. IBM Security Key Lifecycle Manager assists the encryption-capable tape drives in generating, protecting, storing, and maintaining encryption keys.

For more information about and examples of tape encryption, see *IBM System Storage Tape Encryption Solutions,* SG24-7320.

2.2.1 IBM Security Key Lifecycle Manager

IBM Security Key Lifecycle Manager, previously called IBM Tivoli Key Lifecycle Manager, is the IBM strategic platform for storage and delivery of encryption keys to encrypting storage end-point devices.

Security Key Lifecycle Manager provides a simple solution to the complex problem of key management. Traditionally, the more encryption you deploy, the more keys you have to manage. These keys have their own lifecycles, separate from the data that they're protecting, and these lifecycles must managed, from initialization and activation through expiration and destruction. Security Key Lifecycle Manager can help you better manage the encryption key lifecycle, allowing you to simplify, centralize and automate your organization's key-management processes and reduce operational costs.

Security Key Lifecycle Manager serves keys at the time of use to allow for centralized storage of key material in a secure location, a unique approach that supports multiple protocols for serving symmetric and asymmetric keys. Users can also centrally create, import, distribute, back up, archive and manage the lifecycle of those keys using a customizable graphical user interface (GUI).

Security Key Lifecycle Manager provides an easy-to- use, web-based GUI that helps simplify key configuration and management tasks. With this GUI, administrators can easily create keystores, assign keys and manage the lifecycle of both from a centralized console. For more information about the Security Key Lifecycle Manager, see the IBM Security Key Lifecycle Manager Information Center at this website:

`http://www.ibm.com/support/knowledgecenter/SSWPVP_2.5.0/com.ibm.sklm.doc_2.5/welcome.htm`

For more information about this offering, see the IBM Security Key Lifecycle Manager website:

`http://www.ibm.com/software/products/en/key-lifecycle-manager`

Keystore backup: Because of the critical nature of keys in the keystore, ensure the keystore is backed up on a regular basis. This way, it can be recovered as needed and can read the data cartridges that were encrypted by using the certificate with that drive or library. Backups should not be encrypted.

Encryption Key Manager: The legacy product, Encryption Key Manager, should not be downloaded for new tape encryption installations. Encryption Key Manager still can be downloaded by existing Encryption Key Manager customers that implemented Encryption Key Manager, or by IBM i5/OS™ customers who want to run their key manager on i5/OS.

2.2.2 Encryption methods

The encryption methods for the TS1120, TS1130, TS1140, TS1150 and the Ultrium 4, Ultrium 5, and Ultrium 6 tape drives differ slightly. Those differences are described next.

The following sections also contain a brief description of encryption methods. In these sections, we use the term *Key Manager* (KM) to refer to Security Key Lifecycle Manager and any other key managers.

Symmetric key encryption

Encryption of data by using a symmetric key and algorithm is sometimes called *private key encryption* or *secret key*, which is not to be confused with the private key in an asymmetric key system. In a symmetric key system, the cipher key that is used for encrypting data is the same as the cipher key that is used for decryption.

The encryption and decryption ciphers can be related by a simple transformation on the key, or the encryption key and the decryption key can be identical. In the IBM Tape Encryption solution Security Key Lifecycle Manager, the same encryption key is used for encryption and decryption of the data. This key is protected by an asymmetric key algorithm and is never available in clear text.

Symmetric key encryption is several orders of magnitude faster than asymmetric key encryption. Secret key algorithms can support encryption one bit at a time or by specified blocks of bits. The AES standard supports 128-bit block sizes and key sizes of 128, 192, and 256. The IBM Tape Encryption solution uses the AES standard with a 256-bit key. Other well-known symmetric key examples include Twofish, Blowfish, Serpent, Cast5, DES, TDES, and IDEA.

Asymmetric key encryption

Another important method of encryption that is widely used today is referred to as *public/private key encryption* or *asymmetric encryption*. When this encryption methodology is used, ciphers are generated in pairs. The first key is used to encrypt the data, and the second key is used to decrypt the data.

This technique was pioneered in the 1970s and represented a significant breakthrough in cryptography. The RSA algorithm is the most widely used public key technique. The power of this approach is a public key, which is used to encrypt the data. This public key can be widely shared, and anyone who wants to send secure data to an organization can use its public key. The receiving organization then uses its private key to decrypt the data, which makes public/private key encryption useful for sharing information between organizations. This methodology is widely used on the Internet today to secure transactions, including Secure Sockets Layer (SSL).

Asymmetric key encryption is much slower and more computationally intensive than symmetric key encryption. The advantage of asymmetric key encryption is the ability to share secret data without sharing the same encryption key.

Managing encryption

There are three different methods of encryption management available. These methods differ in where the key manager application is located. The operating environment determines which is best, with the result that key management and the encryption policy engine can be in any one of the environmental layers that are described next.

Application-managed tape encryption

The application-managed tape encryption method is best in operating environments that run an application that already is capable of generating and managing encryption policies and keys, such as the IBM Security Key Lifecycle Manager Policies that specify when encryption is to be used are defined through the application interface. The policies and keys pass through the data path between the application layer and the encryption-capable tape drives.

Encryption is the result of interaction between the application and the encryption-enabled tape drive and is transparent to the system and library layers. Because the application manages the encryption keys, volumes written and encrypted with the application method can be read only by using the application-managed tape encryption method.

Application-managed encryption is provided at no cost for those IBM tape drives which support encryption.

System-managed tape encryption

The system-managed tape encryption method can be used for open systems operating environments where there is no application that is capable of key management. Encryption policies that specify when to use encryption are set up through each instance of the IBM device driver. Key generation and management are performed by the key manager, a Java application that is running on the host or externally on another host. Policy controls and keys pass through the data path between the system layer and the TS1120, TS1130, TS1140, TS1150, and Ultrium 4, Ultrium 5, and Ultrium 6 tape drives that are installed in the libraries.

Encryption is transparent to the applications. System-managed tape encryption and library-managed tape encryption are transparent to one another. A tape that is encrypted by using system-managed encryption can be decrypted by using library-managed encryption. The reverse is true, if they both have access to the same key manager keystore.

IBM Security Key Lifecycle Manager is required for enabling system-managed tape encryption for Ultrium 5 and Ultrium 6

Library-managed tape encryption

The library-managed tape encryption method is supported on the following IBM tape libraries:

- TS2900 tape autoloader with Ultrium 4, Ultrium 5, and Ultrium 6 Half-High tape drives
- TS3100 tape library with:
  - Ultrium 4 Full-High and Half-High tape drives
  - Ultrium 5 Full-High and Half-High tape drives
  - Ultrium 6 Full-High and Half-High tape drives
- TS3200 tape library with:
  - Ultrium 4 Full-High and Half-High tape drives
  - Ultrium 5 Full-High and Half-High tape drives
  - Ultrium 6 Full-High and Half-High tape drives

- TS3310 tape library with Ultrium 4, Ultrium 5, and Ultrium 6 Full-High tape drives
- TS3500 tape library with the TS1120, TS1130, TS1140, TS1150, TS1040, TS1050, and TS1060 tape drives
- TS4500 tape library with TS1150, TS1140, TS1050, and TS1060 tape drives

  These tape drives can be installed in the TS3500 tape library, but the TS1120, TS1130, TS1140, TS1150, and LTO tape drives cannot be mixed within the same logical library. However, TS1120, TS1130, TS1140, and TS1150 tape drives can be mixed within the same logical library.

Key generation and management are performed by the key manager, a Java application that is running on a library-attached host. The keys pass through the library-to-drive interface. Therefore, encryption is transparent to the applications. When it is used with certain applications, such as IBM Security Key Lifecycle Manager, library-managed encryption includes support for an internal label option. When the internal label option is configured, the TS1120, TS1130, TS1140, TS1150, Ultrium 4, Ultrium 5, and Ultrium 6 tape drives automatically derive the encryption policy and key information from the metadata that is written on the tape volume by the application.

IBM Security Key Lifecycle Manager is required for enabling library-managed tape encryption for Ultrium 5 and Ultrium 6 tape drives.

System-managed tape encryption and library-managed tape encryption are transparent to one another. A tape that is encrypted by using system-managed encryption can be decrypted by using library-managed encryption. The reverse is true, if they both have access to the same key manager keystore and both use IBM AIX® and the IBM device driver. Otherwise, this capability might not be available.

Important: IBM Security Key Lifecycle Manager is required for enabling system-managed and library-managed tape encryption for Ultrium 5 and Ultrium 6 tape drives

2.2.3 LTO Ultrium tape encryption

The LTO Ultrium tape encryption differs from the 3592 drive encryption. Unlike the TS1120, TS1130, TS1140, and TS1150 tape drives, the Ultrium 4, Ultrium 5, and Ultrium 6 tape drives cannot store a wrapped form of the symmetric encryption key on the tape cartridge. The symmetric encryption key is stored in the keystore that is attached to the key manager. An associated *key identifier* or *alias* maps to the data key in the keystore. This alias is stored with each block of data on the tape. AES 256-bit encryption is used, as with the TS1120, TS1130, TS1140, and TS1150 tape drives, to encrypt and decrypt the data on the data cartridge. The IBM key manager for tape products is Security Key Lifecycle Manager.

2.3 IBM Ultrium 1, 2, 3, 4, 5, and 6 highlights

This section is an overview of the features of IBM Ultrium 1, 2, 3, 4, 5, and 6 tape drives, such as drive and cartridge compatibility, cartridge capacity, and drive performance. An overview of IBM libraries and the multipath architecture also is provided.

2.3.1 IBM Ultrium 1, 2, 3, 4, 5, and 6 compatibility

The following rules describe the compatibility among the various LTO cartridge generations:

- Data cartridges one generation and earlier are read/write compatible.
- Data cartridges two generations and earlier are read only.
- Data cartridges three generations and earlier are not supported.

Ultrium 6 drives can read and write Ultrium 5 cartridges, and read only Ultrium 4 cartridges, and thus can interchange data with Ultrium 5 and Ultrium 4 tape drives. However, the Ultrium 6 drive allows only an Ultrium 5 cartridge to be written at the LTO Generation 5 operating point (1500 GB). More specifically, the Ultrium 6 drive does not allow an Ultrium 5 cartridge (1500 GB) to be re-formatted to the Ultrium 6 format (2500 GB). This concept is generally true when a data cartridge is used in a higher generation LTO Ultrium tape drive.

Table 2-7 shows the read/write compatibility among the six generations of data cartridges.

Table 2-7 Ultrium data cartridge compatibility

IBM Ultrium tape drive	**IBM TotalStorage LTO Ultrium Data Cartridge**					
	2500 GB (Ultrium 6	**1500 GB (Ultrium 5)**	**800 GB (Ultrium 4)**	**400 GB (Ultrium 3)**	**200 GB (Ultrium 2)**	**100 GB (Ultrium 1)**
Ultrium 6	Read/Write	Read/write	Read only	N/A	N/A	N/A
Ultrium 5	N/A	Read/write	Read/write	Read only	N/A	N/A
Ultrium 4	N/A	N/A	Read/write	Read/write	Read only	N/A
Ultrium 3	N/A	N/A	N/A	Read/write	Read/write	Read only
Ultrium 2	N/A	N/A	N/A	N/A	Read/write	Read/write
Ultrium 1	N/A	N/A	N/A	N/A	N/A	Read/write

The various generations of data cartridges can be recognized quickly by the case color or media identifier at the right side of the bar code label. Table 2-8 shows the different case colors and media identifiers for the different LTO Ultrium generations.

Table 2-8 Cartridge color and media identifier

LTO Ultrium Data Cartridge	Case color	Media identifier
LTO Ultrium 1	Black	L1
LTO Ultrium 2	Purple	L2
LTO Ultrium 3	Slate Blue	L3
LTO Ultrium 4	Green	L4
LTO Ultrium 5	Burgundy	L5
LTO Ultrium 6	Black	L6
LTO Ultrium 3 WORM	Slate Blue and Silvery Gray	LT
LTO Ultrium 4 WORM	Green and Silvery Gray	LU
LTO Ultrium 5 WORM	Burgundy and Silvery Gray	LV
LTO Ultrium 6 WORM	Black and Silvery Gray	LW

2.3.2 LTO performance

IBM LTO drives provide high performance and continue to improve with each new generation of products. Applications that are highly dependent on tape-processing speed can benefit from the significant performance that is provided by the LTO Ultrium tape drives.

IBM LTO Ultrium drives provide high-speed tape operations and relief to users who have difficulty completing tape activities in the time available. For those applications with limited system backup windows or have large amounts of disk data to back up, LTO Ultrium tape drives are ideal.

By using the built-in data-compression capability of the LTO Ultrium drive, far greater data rates than the uncompressed data rate can potentially be achieved. However, the actual throughput is a function of many components, such as the host system processor, disk data rate, block size, data compression ratio, SCSI bus capabilities, and system or application software. Installing multiple tape drives in general (or more than two in the case of IBM LTO) on a single SCSI bus can adversely affect data transfer rates.

IBM LTO Ultrium 1 tape drive

The IBM LTO Ultrium 1 tape drive has the following performance characteristics:

- 15 MBps native sustained data transfer rate
- 30 MBps sustained data transfer rate at a 2:1 compression ratio
- 60 MBps maximum sustained data rate (at maximum compression)
- 100 MBps burst data transfer rate for Fibre Channel
- 80 MBps burst data transfer rate for Ultra2 SCSI LVD drives
- 40 MBps burst data transfer rate for Ultra SCSI HVD drives
- 20 s nominal load-to-ready time
- 18 s nominal unload time
- 73 s average search time to first byte of data
- 110 s maximum rewind time
- 4 mps read/write speed

- 6 mps search/rewind speed
- 32 MB buffer

IBM LTO Ultrium 2 tape drive

The IBM LTO Ultrium 2 Drives provide more than twice the performance of IBM Ultrium 1 with sustained data rates of 35 MBps native and 70 MBps with a 2:1 compression ratio. IBM Ultrium 2 has faster load and unload time, faster data access time, faster rewind time, and faster cartridge fill time compared to IBM Ultrium 1. The Ultrium 2 drive provides speed matching with five speeds for the Ultrium 2 cartridge. The Ultrium 2 drive also reads and writes to an Ultrium 1 cartridge at a higher speed than the Ultrium 1 drive.

The IBM LTO Ultrium 2 tape drive has the following performance characteristics:

- 35 MBps native sustained data transfer rate
- 70 MBps sustained data transfer rate at a 2:1 compression ratio
- 110 MBps maximum sustained data rate (at maximum compression)
- 200 MBps burst data transfer rate for Fibre Channel
- 160 MBps burst data transfer rate for Ultra 160 SCSI LVD drives
- 40 MBps burst data transfer rate for Ultra SCSI HVD drives
- 15 s nominal load-to-ready time
- 15 s nominal unload time
- 49 s average search time to first byte of data
- 80 s maximum rewind time
- 6.2 mps read/write speed
- 8 mps search/rewind speed
- 64 MB buffer

IBM LTO Ultrium 3 tape drive

The IBM LTO Ultrium 3 Drives offer more than double the performance of IBM Ultrium 2 with sustained data rates of 80 MBps native and 160 MBps with a 2:1 compression ratio. IBM Ultrium 3 provides speed matching with five speeds for Ultrium 3 and Ultrium 2 cartridges and reads and writes an Ultrium 2 cartridge at the speed of the Ultrium 2 drive.

The IBM LTO Ultrium 3 tape drive has the following performance characteristics:

- 80 MBps native sustained data transfer rate
- 160 MBps sustained data transfer rate at a 2:1 compression ratio
- Over 200 MBps maximum sustained data rate (at maximum compression)
- 200 MBps burst data transfer rate for Fibre Channel
- 160 MBps burst data transfer rate for Ultra 160 SCSI LVD drives
- 15 s nominal load-to-ready time
- 15 s nominal unload time
- 54 s average search time to first byte of data
- 88 s maximum rewind time
- 6.2 mps read/write speed
- 8 mps search/rewind speed
- 128 MB buffer (256 MB in the Half-High v2 drive)

IBM LTO Ultrium 4 tape drive

The IBM LTO Ultrium 4 tape drive has the following performance characteristics:

- 120 MBps native sustained data transfer rate
- Sustained data transfer rate at a 2:1 compression ratio:
  - For SCSI, 140 MBps
  - For SAS, 240 MBps
  - For FC, 240 MBps
- 12 s nominal load-to-ready time
- 17 s nominal unload time
- 57 s average search time to first byte of data
- 54 s average rewind time
- 8 mps read/write speed
- 8 mps rewind speed
- 256 MB buffer

IBM LTO Ultrium 5 tape drive

The IBM LTO Ultrium 5 tape drive has the following performance characteristics:

- 140 MBps native sustained data transfer rate
- Sustained data transfer rate at a 2:1 compression ratio:
  - For SAS, 280 MBps
  - For USB, 280 MBps
  - For FC, 280 MBps
- 12 s nominal load-to-ready time
- 17 s nominal unload time
- Average search time to first byte of data:
  - 49 s for a Full-High drive
  - 72 s for a Half-High drive
- Average rewind time
  - 60 s for a Full-High drive
  - 75 s for a Half-High drive
- 6 mps read/write speed
- Rewind speed
  - 10 mps for a Full-High drive
  - 6.4 mps for a Half-High drive
- Data buffer size
  - 512 MB for a Full-High drive
  - 256 MB for a Half-High drive

IBM LTO Ultrium 6 tape drive

The IBM LTO Ultrium 6 tape drive has the following performance characteristics:

- 160 MBps native sustained data transfer rate
- Sustained data transfer rate at a 2.5:1 compression ratio
  - For SAS, 400 MBps,
  - For USB, 400 MBps
  - For FC, 400 MBps
- 12 s nominal load-to-ready time
- 17 s nominal unload time
- Average search time to first byte of data
  - 49 s for a Full-High drive
  - 60 s for a Half-High drive
- Average rewind time
  - 42 s for a Full-High drive
  - 62 s for a Half-High drive
- 6.8 mps read/write speed
- Rewind speed
  - 10 mps for a Full-High drive
  - 9 mps for a Half-High drive
- Data buffer size
  - 1024 MB for a Full-High drive
  - 512 MB for a Half-High drive

2.3.3 Reliability

The IBM LTO Ultrium tape format differs from earlier non-Ultrium IBM products. The Ultrium technology has the following reliability and availability features:

- Data integrity

  The drive performs a read after write for verification. Incorrectly written data, such as the result of a tape defect, is automatically rewritten by the drive in a new location. Data rewritten as the result of media defects is not counted against the drive error performance.

  The drive never records incorrect data to the tape media without posting an error condition.

- Power loss

  No recorded data is lost as a result of normal or abnormal power loss while the drive is reading or writing data. If power is lost while writing data, only the data block that is being written might be in error. Any previously written data is not destroyed.

- Error correction

  Data integrity features include two levels of error correction that can provide recovery from longitudinal media scratches.

- Integrated head cleaner

  The head of the drive must be kept clean to prevent errors that are caused by contamination. During the load process, a brush integrated into the drive mechanism cleans the head before it is used with the tape. This brush keeps the head and media free of debris on a continuing basis and requires fewer drive-cleaning operations.

- Surface Control Guiding Mechanism

  The Surface Control Guiding Mechanism, which is patented by IBM, guides the tape along the tape path by using the surface of the tape rather than the edges to control tape motion. By using grooved rollers (as shown in Figure 2-22), an air cushion builds between the tape and the rollers that keep the tape in the right position. On LTO Ultrium 5 and Ultrium 6, flangeless rollers are installed on all four rollers for Full-High tape drives to allow the tape to float naturally. Ultrium 6 Half-High drive rollers are semi-flangeless; only two of the rollers are flanged.

  This feature helps to prevent tape damage (especially to the edges of the tape) and debris build-up on the roller that can accumulate in the head area, which minimizes the chance of physical damage to the tape media.

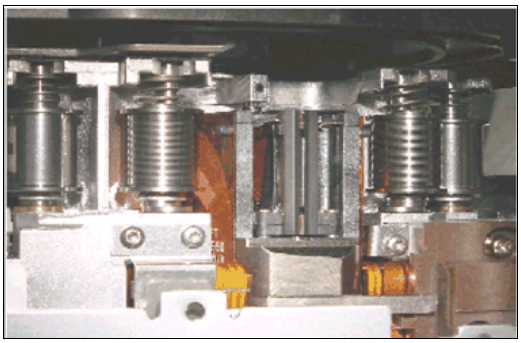


Figure 2-22 Surface Control Guiding Mechanism

- Flat lap head

  The flat lap head (as shown in Figure 2-23) improves contact between the read and write recording elements and the tape, which increases the quality of the recording and readback of data.

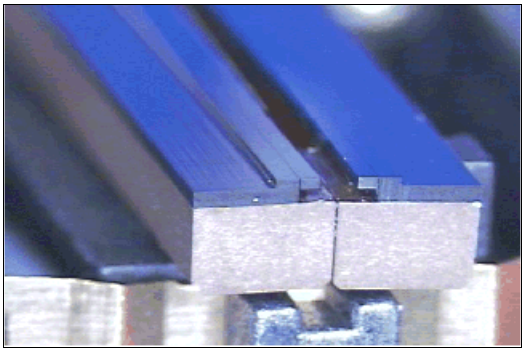


Figure 2-23 Flat lap head

The Surface Control Guiding Mechanism and the flat lap head help minimize debris that is generated as the tape moves through its path, which resulting in increased reliability of reading and writing data. This feature also potentially increases the life expectancy of the media by not using the edges of the tape to guide it over the read/write head, which historically was a major source of debris on the tape path.

- Statistical Analysis and Reporting System

  Statistical Analysis and Reporting System (SARS) is another IBM exclusive feature. Only IBM LTO drives provide this level of preventive diagnostic reporting. (For more information about reporting, see 12.2.6, “Tape System Reporter” on page 429.) The Ultrium drive uses this reporting system to assist in isolating failures between media and hardware. SARS uses the cartridge performance history that is saved in the cartridge memory module and the drive performance history kept in the drive flash EEPROM to determine the most likely cause of failure. It can then cause the drive to request a cleaner tape, to mark the media as degraded, and to indicate that the hardware has degraded. SARS reports the results of its analysis in the form of a Tape Alert, if necessary.

2.4 IBM LTO Ultrium 6 tape drives

The latest LTO technology, Ultrium 6, was released in 2012. IBM Ultrium 6 offerings represent significant improvements in capacity and performance over the previous generation, Ultrium 5, while protecting investment in the previous technology.

The Ultrium 6 tape drive is a high-performance, high-capacity tape drive. The drive records data by using a linear serpentine recording format on half-inch tape that is housed within a cartridge. The data tracks are located by using preformatted servo tracks.

Ultrium 6 tape drive provides the following improvements over the older Ultrium 5 models:

- Increases the native transfer speed to 160 MBps compared with 140 MBps for Ultrium 5 tape drive
- Increases the compressed speed to 400 MBps compared with Ultrium 5’s 280 MBps
- More than doubles the potential capacity of a cartridge in Ultrium 5 format

Ultrium 6 tape drive features at a glance

The LTO Generation 6 tape drive range has the following characteristics:

- Native data transfer rate of up to 160 MBps
- Compressed data transfer rate of up to 400 MBps
- LTO Ultrium 6 data and WORM tape cartridge native physical capacity of up to 2.5 TB
- 8 Gbps Fibre Channel attachment option
- 6 Gbps SAS dual port attachment option
- USB 3.0 single port and 6 Gbps SAS single port attachment option
- 1024 MB internal data buffer for Full-High drives
- 512 MB internal buffer for Half-High drives
- Application-managed encryption support
- System-managed and Library-Managed encryption support for non-stand-alone drives
- 16 KB cartridge memory with Ultrium 6 media
- LTFS single drive-use and Library Edition support
- IBM Linear Tape File System partitioning support

Compatibility

In addition to reading and writing to LTO Ultrium 6 tape cartridges, the Ultrium 6 tape drives can read and write to LTO Ultrium 5 cartridges and read LTO Ultrium 4 cartridges. They cannot read Ultrium 1, Ultrium 2, or Ultrium 3 cartridges.

The drive also writes to tapes that can be read by other licensed LTO Ultrium 6 drives. In addition to using the IBM LTO Ultrium Data Cartridge with up to 2500 GB capacity, the drive offers read/write capability for certified LTO Ultrium 6 tape cartridges.

Table 2-9 shows the native data transfer rate when a data cartridge of another generation is processed.

Table 2-9 Native data transfer rate with various media

	Generation 6 media	Generation 5 media	Generation 4 media
Supported methods of Operating	Read/write	Read/write	Read/write
Native date rate SAS and USB (MBps)	160	140	120
Native data rate Fibre Channel (MBps)	160	140	120

Connectivity

The LTO Ultrium 6 tape drive family offers high capacity, performance and technology for the midrange open systems environment. These drives offer the following connection types:

- 6 Gbps SAS for point-to-point attachment (not in TS3310 or TS1060/TS3500 configuration)
- 8 Gbps Fibre Channel interface for point-to-point or FC-AL attachment (not on TS2260 or TS2360)
- USB 3.0 Type B connector attachment for TS2260 only.

IBM Ultrium drives can be connected to many different types of servers. For a list of server interface cards or Host-Bus-Adapters (HBAs) that are supported with the Ultrium drives, see this website:

`http://www.ibm.com/systems/support/storage/ssic`

Performance

The LTO Ultrium 6 tape drive uses 2176 data tracks to read and write to Ultrium 6 tape. These tracks are grouped in five servo bands. Like the Ultrium 5 drives, the high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

The native data transfer rate for Ultrium 6 tape drives is 160 MBps. Compressed data rates can reach 400 MBps. IBM suggests the use of the IBM TotalStorage LTO Ultrium 6 2500 GB data cartridge, which provides up to 6250 GB of storage with a 2.5:1 compression ratio.

Dynamic speed matching

The LTO Ultrium 6 tape drive performs *dynamic speed matching* at one of 14 speeds to adjust the native data rate of the drive as closely as possible to the net host data rate (after factoring out data compressibility). This approach helps to reduce the number of backhitch repositions and improves throughput performance. *Backhitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is the result of a mismatch between the data rates of the connected server and the tape drive.

Table 2-10 on page 80 shows the data rates for the LTO Ultrium 6 Drives.

Table 2-10 LTO-6 Drive speed matching data rates

Performance Parameters	Generation 6 Media	Generation 5 Media	Generation 4 Media
Speed matching data rates MBps	160.00 150.77 141.54 132.31 123.08 113.85 104.62 95.38 86.15 76.92 67.69 58.46 49.23 40.00	140.0 130.0 120.0 112.7 105.5 98.2 90.9 83.6 76.4 69.1 61.8 53.5 46.3 40.0	120.0 113.1 106.1 99.2 92.3 85.3 78.6 71.4 64.6 57.6 50.8 43.8 36.9 30.5

Encryption

The LTO Ultrium 6 tape drive family is encryption-capable and supports application-managed tape encryption at no charge on the SAS and Fibre Channel tape drives. In case of library use, system-managed tape encryption and library-managed tape encryption are supported with the Transparent LTO Encryption features (FC5901 for TS2900, FC1604 for TS3500, FC5900 for all other libraries). IBM Security Key Lifecycle Manager is required for encryption key management with LTO Ultrium 6 drives.

Statistical Analysis and Reporting System

The Ultrium 6 tape drives use the Statistical Analysis and Reporting System (SARS) to help isolate failures between media and hardware. The SARS uses the data cartridge performance history that is saved in the cartridge memory module and the drive performance history that is kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape, to mark the media as degraded, and to indicate that the hardware degraded.

IBM Linear Tape File System software application

IBM Ultrium 6 tape drives are compatible with the IBM Linear Tape File System (LTFS) software application. LTFS uses the LTO Ultrium 6 and Ultrium 5 media partitioning functionality. LTFS provides a standard tape cartridge format at low cost and can be used without other database applications. LTFS presents tape media as though it were a file system on a disk drive. LTFS supports only IBM LTO Ultrium 5, Ultrium 6 and IBM 3593-E07 tape drives.

Tape as a storage medium has many benefits: it is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use, has no standard format, and data often cannot be used without first copying it to disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as easy and intuitive as using a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. Users can run any application that is designed for disk files against tape data without concern for the fact that the data is physically stored on tape.

LTFS implements a true file system for tape. LTFS also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM LTFS provides support for IBM tape automation in addition to the single drive edition IBM Linear Tape File System. By using LTFS Library Edition, you can create a single file system mount point for a logical library that is managed by a single instance of LTFS, which runs on a single computer system. In addition, it provides for caching of tape indexes and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges

For more information about LTFS, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

2.4.1 The IBM LTO Ultrium 6 tape drive range

The IBM LTO Ultrium 6 drive range is a mix of Half-High and Full-High stand-alone and library-installable drives. This offers high-performance, high-capacity data storage devices to back up and restore open systems applications. The drive can be integrated into an enclosure, such as a desktop unit, tape autoloader, or tape library.

The IBM LTO Ultrium 6 drive range consists of the following components:

- TS2360 (3580 Model S63) SAS Full-High stand-alone drive
- TS2260 (3580 Model H6S) two port SAS Half-High stand-alone drive
- TS2260 (3580 Model H6S FC 5760) single SAS and USB 3.0 port, Half-High stand-alone drive
- Ultrium 6 SAS Half-High tape drive sled inside a TS2900 tape autoloader
- Ultrium 6 SAS Half-High tape drive sled inside a TS3100 tape library
- Ultrium 6 FC Half-High or Full-High tape drive sled inside a TS3100 tape library
- Ultrium 6 SAS half-High tape drive sled inside a TS3200 tape library
- Ultrium 6 FC Half-High or Full-High tape drive sled inside a TS3200 tape library
- Ultrium 6 FC tape drive sled inside a TS3310 tape library
- TS1060 (3588 F6A) FC tape drive sled within a TS3500 tape library
- TS1060 (3988 F6C) FC tape drive sled within a TS4500 tape library

IBM TS2360 (3580 S63) tape drive S63

IBM TS2360 tape drive model S63 (3580 S63) is an external Full-High (4 EIA units high) stand-alone or rack mountable unit that offers high capacity and performance for the midrange systems environment.

The TS2360 model S63 tape drive uses a 6 Gbps dual port SAS interface for connection to a wide spectrum of system servers. The new TS2360 attaches to selected IBM Power Systems™ models and to IBM System x and PC servers. The TS2360 also supports Microsoft Windows, HP-UX, Oracle Solaris, and UNIX. The two ports per drive are available to improve availability and ease of attachment. The Ultrium 6 SAS drive attempts to connect at 6 Gbps, but auto-negotiates down to 3 Gbps or even 1.5 Gbps if the system it is connected to cannot support 6 Gbps or has problems on the physical connection. Expander use is not supported.

The TS2360 can read and write to Ultrium 6 and Ultrium 5 cartridges and is read compatible with Ultrium 4 data cartridges. The Ultrium 6 tape drive is encryption-capable and supports application managed encryption.

IBM LTFS Standalone Drive Edition (LTFS SDE) software is included with each TS2360 tape drive. LTFS uses LTO-6 tape drive partitioning. It enables a self-describing tape file format and to deliver an easy tape storage and distribution solution without the use of more database applications. Customers of IBM LTFS software are those who require a standard tape cartridge format at a low cost and use stand-alone IBM LTO-5 or LTO-6 tape drives.

The enclosure width allows two TS2360 storage units to be mounted side by side in a 19-inch IBM server rack mount shelf kit that requires three EIA units (3U) of rack space.

The TS2360 tape drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4 inch (QIC), 4 mm (DAT), 8 mm, or older LTO generation tape drives.

There are no unique power supply requirements. The TS2360 tape drive can attach to 100V to 125V power supplies at 60Hz or 200V to 240V supplies at 50 Hz AC.

IBM LTO Ultrium 6 Full-High tape drives have an internal buffer of 1024 megabytes.

For more information about the TS2360 Ultrium tape drive, see Chapter 5, “IBM TS2360 tape drive” on page 177.

Figure 2-24 shows a TS2360 Full-High LTO Ultrium 6 tape drive.



Figure 2-24 TS2360 LTO Ultrium 6 tape drive

IBM TS2260 (3580 H6S) tape drive H6S

IBM TS2260 tape drive model H6S (3580 H6S) is an external Half-High (2 EIA units high) stand-alone or rack-mountable unit that offers high capacity and performance for the midrange systems environment.

The TS2260 Model H6S tape drive uses a dual-port 6 Gbps SAS (serial-attached SCSI) host interface or an optional single 6 Gbps SAS and single USB 3.0 port. The new TS2260 attaches to selected IBM Power Systems models and to IBM System x and PC servers. The TS2260 also supports Microsoft Windows, HP-UX, Oracle Solaris, and UNIX.

There are two options for host connectivity:

SAS connectivity only	The two ports per drive are available to improve availability and ease of attachment. The Ultrium 6 SAS drive attempts to connect at 6 Gbps, but automatically negotiates down to 3 Gbps or even 1.5 Gbps if the system that it is connected to cannot support 6 Gbps or has problems on the physical connection. Expander use is not supported.
SAS or USB connectivity	A single SAS port and a single USB port host interface are provided. The single-port SAS connector provides the same 6 Gbps connectivity as the dual port, while the USB host interface supports USB 3.0 connectivity and can negotiate a Super Speed transfer rate. It also supports USB 2.0 connectivity at the slower transfer rates. The USB interface automatically negotiates speed. There are no configurable topologies, so no feature switches associated with USB. The tape drive with SAS or USB ports requires a device driver for USB 3.0 operation.

The TS2260 can read and write to Ultrium 6 and Ultrium 5 cartridges, and is read-compatible with Ultrium 4 data cartridges. The Ultrium 6 tape drive is encryption-capable and supports application managed encryption.

IBM LTFS Standalone Drive Edition (LTFS SDE) software is included with each TS2260 tape drive. LTFS uses LTO-6 tape drive partitioning. It enables a self-describing tape file format and to deliver an easy tape storage and distribution solution without the use of more database applications. Customers of IBM LTFS software are those who require a standard tape cartridge format at a low cost and use stand-alone IBM LTO-5 or LTO-6 tape drives.

The enclosure width allows two TS2260 storage units to be mounted side by side in a 19-inch IBM server rack mount shelf kit that requires two EIA units (2U) of rack space.

The TS2260 tape drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4 inch (QIC), 4 mm (DAT), 8 mm, or older LTO generation tape drives.

There are no unique power supply requirements. The TS2260 tape drive can attach to 100V to 125V power supplies at 60Hz or 200V to 240V supplies at 50 Hz AC.

IBM LTO Ultrium 6 Half-High tape drives have an internal buffer of 512 Megabytes.

For a more information about the TS2260 Ultrium tape drive, see Chapter 4, “IBM TS2260 tape drive” on page 167.

Figure 2-25 on page 84 shows a TS2260 Half-High LTO Ultrium 6 tape drive.



Figure 2-25 TS2260 LTO Ultrium 6 tape drive

IBM LTO Ultrium 6 library drives

The library-installable Ultrium 6 tape drives can read and write to Ultrium 6 and Ultrium 5 cartridges and are read-compatible with Ultrium 4 data cartridges.

The LTO Ultrium 6 tape drives support data encryption on the base drive with Ultrium 6 or Ultrium 5 media. System Managed and Library Managed Encryption and associated IBM Security Key Lifecycle Manager access are available as a chargeable licensed key, Transparent LTO Encryption (feature code 5901 for TS2900, feature code 5900 for TS3100 or 3200, and feature code 1604 for TS3500 libraries). IBM Security Key Lifecycle Manager is required with this feature.

The Ultrium 6 and Ultrium 5 drives support media partitioning and the use of the IBM Linear Tape File System Library Edition (LTFS LE) and LTFS EE if installed in a supported library.

For more information about LTFS, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

For more information about LTFS EE, see *IBM Linear Tape File System Enterprise Edition V1.1.1.2 Installation and Configuration Guide, SG24-8143.*

IBM LTO Ultrium 6 Full-High library drives

IBM LTO Ultrium 6 Full-High (4 EIA units high) drives are available for use in the TS3100, TS3200, TS3310, TS3500, and TS4500 libraries. The following drives are specified and ordered with the library:

- The TS3100 library can accommodate one Ultrium 6 SAS or FC Full-High tape drive.
- The TS3200 library can accommodate two Ultrium 6 SAS or FC Full-High tape drives.
- The TS3310 base L5B unit can accommodate two Ultrium 6 FC Full-High tape drives.
- The TS3310 optional E9U expansion unit can accommodate four Ultrium 6 FC Full-High tape drives.
- The TS3500 libraries can accommodate up to 192 TS1060 drives, depending on their base and expansion frame configurations.

- The TS4500 libraries can accommodate up to 60 TS1060 drives, depending on their base and expansion frame configurations.

IBM LTO Ultrium 6 Full-High tape drives have an internal buffer of 1024 MBs.

IBM LTO Ultrium 6 Half-High library drives

IBM LTO Ultrium 6 Half-High (2 EIA units high) drives are available for use in the TS2900, TS3100, and TS3200 libraries. The following drives are specified and ordered with the library:

- The TS2900 autoloader can accommodate one Ultrium 6 SAS Half-High tape drive.
- The TS3100 library can accommodate two Ultrium 6 SAS or FC Half-High tape drive.
- The TS3200 library can accommodate four Ultrium 6 SAS or FC Half-High tape drives.

IBM LTO Ultrium 6 Half-High tape drives have an internal buffer of 512 MBs.

2.5 IBM LTO Ultrium 5 tape drives

The IBM LTO Ultrium 5 drives were released in 2010. At the time, IBM Ultrium 5 offerings represented significant improvements in capacity and performance over the previous generation, Ultrium 4, while protecting investment in the previous technology.

The Ultrium 5 tape drive is a high-performance, high-capacity tape drive. The drive records data by using a linear serpentine recording format on half-inch tape that is housed within a cartridge. The data tracks are located by using preformatted servo tracks.

Ultrium 5 tape drive features at a glance

The LTO Generation 5 tape drive range has the following characteristics:

- Native data transfer rate of up to 140 MBps
- Compressed data transfer rate of up to 280 MBps
- LTO Ultrium 5 data and WORM tape cartridge native physical capacity of up to 1.5 TB
- 8 Gbps Fibre Channel attachment option
- 6 Gbps SAS dual port attachment option
- USB 3.0 single port and 6 Gbps SAS single port attachment option
- 512 MB internal data buffer for Full-High drives
- 256 MB internal buffer for Half-High drives
- Application-managed encryption support
- System-managed and library-managed encryption support for non-stand-alone drives
- 8 KB cartridge memory with Ultrium 5 media
- LTFS single drive-use and Library Edition support
- IBM Linear Tape File System partitioning support

Compatibility

In addition to reading and writing to LTO Ultrium 5 tape cartridges, the Ultrium 5 tape drives can read and write to LTO Ultrium 4 cartridges and read LTO Ultrium 3 cartridges. However, it cannot read LTO Ultrium 1 or Ultrium 2 cartridges.

The drive also writes to tapes that can be read by other licensed LTO Ultrium 5 drives. In addition to the use of the IBM LTO Ultrium Data Cartridge with up to 1500 GB capacity, the drive offers read/write capability for certified LTO Ultrium 5 tape cartridges.

Table 2-11 shows the native data transfer rate when a data cartridge of another generation is processed.

Table 2-11 Native data transfer rate with various media

	Generation 5 media	Generation 4 media	Generation 3 media
Supported methods of Operating	Read/write	Read/write	Read only
Native date rate SAS and USB (MBps)	140	120	80
Native data rate Fibre Channel (MBps)	140	120	80

Connectivity

The LTO Ultrium 5 tape drive family offers high capacity, performance, and technology for the midrange open systems environment. These drives offer the following connection types:

- 6 Gbps SAS for point-to-point attachment (not in TS3310 or TS1050/TS3500 configuration)
- 8 Gbps Fibre Channel interface for point-to-point or FC-AL attachment (not on TS 2250 or TS2350)
- USB 3.0 Type B connector attachment for TS2250 only.

IBM Ultrium drives can be connected to many different types of servers. For a list of server interface cards or Host-Bus-Adapters (HBAs) that are supported with the Ultrium drives, see this website:

`http://www.ibm.com/systems/support/storage/ssic`

Performance

The LTO Ultrium 5 tape drive uses 1280 data tracks to read and write to Ultrium 5 tape. These tracks are grouped in five servo bands. Like the Ultrium 4 drives, the high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

The native data transfer rate for Ultrium 5 tape drives is 140 MBps. Compressed data rates can reach 280 MBps. IBM advises the use of the IBM TotalStorage LTO Ultrium 5 1500 GB data cartridge, which provides up to 3000 GB of storage with a 2:1 compression ratio.

Dynamic speed matching

The LTO Ultrium 5 tape drive performs *dynamic speed matching* at one of 14 speeds to adjust the native data rate of the drive as closely as possible to the net host data rate (after factoring out data compressibility). This approach helps to reduce the number of backhitch repositions and improves throughput performance. *Backhitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is the result of a mismatch between the data rates of the connected server and the tape drive.

Table 2-12 on page 87 shows the speed matching data rates for the LTO Ultrium 5 Drives.

Table 2-12 LTO-5 Drive speed matching data rates

Performance parameters	Generation 5 media	Generation 4 media	Generation 3 media
Speed-matching data rates MBps	140.0 130.0 120.0 112.7 105.5 98.2 90.9 83.6 76.4 69.1 61.8 53.5 46.3 40.0	120.0 113.1 106.1 99.2 92.3 85.3 78.6 71.4 64.6 57.6 50.8 43.8 36.9 30.5	80.0 76.1 72.3 68.4 64.6 60.8 56.9 53.1 49.2 45.4 41.5 37.7 33.8 30.0

Encryption

The LTO Ultrium 5 tape drive family is encryption-capable and supports application-managed tape encryption at no charge on the SAS and Fibre Channel tape drives. In case of library use, system-managed tape encryption and library-managed tape encryption are supported with the Transparent LTO Encryption features (FC5901). IBM Security Key Lifecycle Manager is required for encryption key management with LTO Ultrium 5 Drives.

Giant magneto-resistive head design

The LTO Ultrium 5 tape drive uses the giant magneto-resistive (GMR) head with beveled contouring for reducing friction (“stiction”), especially with smoother LTO Ultrium 5 media type. This head design is well-proven in Enterprise Tape products and helps minimize contact, edge damage, debris accumulation, and wear on the tape as it moves over the read/write heads.

Surface Control Guiding Mechanism

The Surface Control Guiding Mechanism guides the tape along the tape path in the LTO Ultrium 5 tape drive. This method uses the surface of the tape rather than the edges to control tape motion. LTO Ultrium 5 Full-High tape drives use flangeless rollers so that the media can float naturally. LTO Ultrium 5 Half-High tape drives do not have flangeless rollers. The tape path is similar to the path for the LTO Ultrium 4 Half-High tape drive. The Surface Control Guiding Mechanism helps to reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

Statistical Analysis and Reporting System

The Ultrium 5 tape drive uses the Statistical Analysis and Reporting System (SARS) to help isolate failures between media and hardware. The SARS uses the data cartridge performance history saved in the cartridge memory module and the drive performance history kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape, to mark the media as degraded, and to indicate that the hardware has degraded. When a drive memory dump is taken from the drive, the Support Center can determine if the failure is in the tape drive or on the data cartridge.

Media partitioning

Media partitioning is now available with the LTO Ultrium 5 drive. Media partitioning allows for faster data access by splitting the cartridge into two media partitions. WORM media is not partitionable.

IBM Linear Tape File System software application

The release of the IBM Linear Tape File System (LTFS) software application uses the LTO Ultrium Generation 5 media partitioning functionality. LTFS provides a standard tape cartridge format at low cost and can be used without more database applications. LTFS presents tape media as though it were a file system on a disk drive. It supports only IBM LTO Ultrium 5 tape drives or higher generation IBM LTO Ultrium tape drives

Tape as a storage medium has many benefits: it is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use, it has no standard format, and data often cannot be used without first copying it to disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as intuitive as the use of a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. You can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

LTFS, which works on Ultrium 5, Ultrium 6, and 3592-E07 drives, implements a true file system for tape. LTFS also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM LTFS provides support for IBM tape automation in addition to the single drive edition IBM Linear Tape File System. LTFS Library Edition provides the ability to create a single file system mount point for a logical library that is managed by a single instance of LTFS, which is running on a single computer system. In addition, it provides for caching of tape indexes, and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges

For more information about LTFS, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

2.5.1 The IBM LTO Ultrium 5 tape drive range

The IBM LTO Ultrium 5 drive range is a mix of Half-High and Full-High stand-alone and library-installable drives. This offers a high-performance, high-capacity data storage devices that back up and restore open systems applications. The drive can be integrated into an enclosure, such as a desktop unit, tape autoloader, or tape library.

The IBM LTO Ultrium 5 drive range consists of the following components:

- TS2350 (3580 Model HS53) SAS Full-High stand-alone drive
- TS2250 (3580 Model H5S) two port SAS Half-High stand-alone drive
- TS2250 (3580 Model H5S FC 5760) single-port SAS and USB, Half-High stand-alone drive
- Ultrium 5 SAS Half-High tape drive sled inside a TS2900 tape autoloader
- Ultrium 5 SAS Half-High tape drive sled inside a TS3100 tape library
- Ultrium 5 FC Half-High or Full-High tape drive sled inside a TS3100 tape library
- Ultrium 5 SAS half-High tape drive sled inside a TS3200 tape library
- Ultrium 5 FC Half-High or Full-High tape drive sled inside a TS3200 tape library

- Ultrium 5 FC tape drive sled inside a TS3310 tape library
- TS1050 (3588 F5A) FC tape drive sled within a TS3500 tape library
- TS1050 (3988 F5C) FC tape drive sled within a TS4500 tape library

IBM TS2350 (3580 HS53) tape drive HS53

IBM TS2350 tape drives model HS53 (3580 HS53) is an external Full-High (4 EIA units high) stand-alone or rack mountable unit that offers high capacity and performance for the midrange systems environment.

The TS2350 Model HS53 tape drive uses a 6 Gbps dual port SAS interface for connection to a wide spectrum of system servers. The TS2350 attaches to selected IBM Power Systems models and to IBM System x and PC servers. The TS2350 also supports Microsoft Windows, HP-UX, Oracle Solaris, and UNIX. The two ports per drive are available to improve availability and ease of attachment. The Ultrium 5 SAS drive attempts to connect at 6 Gbps, but auto-negotiates down to 3 Gbps or even 1.5 Gbps if the system it is connected to cannot support 6 Gbps or has problems on the physical connection. Expander use is not supported.

The TS2350 can read and write to Ultrium 5 and Ultrium 4 cartridges and is read compatible with Ultrium 3 data cartridges. The Ultrium 5 tape drive is encryption-capable and supports application managed encryption.

IBM LTFS Standalone Drive Edition (LTFS SDE) software is included with each TS2350 tape drive. LTFS uses LTO-5 tape drive partitioning. It enables a self-describing tape file format and to deliver an easy tape storage and distribution solution without the use of more database applications. IBM LTFS software clients are those who require a standard tape cartridge format at a low cost and use stand-alone IBM LTO-6 tape drives.

The enclosure width allows two TS2350 storage units to be mounted side by side in a 19-inch IBM server rack mount shelf kit that requires four EIA units (4U) of rack space.

The TS2350 tape drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4 inch (QIC), 4 mm (DAT), 8 mm, or older LTO generation tape drives.

There are no unique power supply requirements. The TS2360 tape drive can attach to 100V to 125V power supplies at 60Hz or 200V to 240V supplies at 50 Hz AC.

IBM LTO Ultrium 5 Full-High tape drives have an internal buffer of 512 Megabytes.

Figure 2-26 shows a TS2350 Full-High LTO Ultrium 5 tape drive.



Figure 2-26 TS2350 LTO Ultrium 5 tape drive

IBM TS2250 (3580 H5S) tape drive H5S

IBM TS2250 tape drive model H5S (3580 H5S) is an external Half-High (2 EIA units high) stand-alone or rack mountable unit that offers high capacity and performance for the midrange systems environment.

The TS2250 Model H5S tape drive uses a dual-port 6 Gbps SAS (serial-attached SCSI) host interface or an optional single 6 Gbps SAS and single USB 3.0 port. The new TS2250 attaches to selected IBM Power Systems models and to IBM System x and PC servers. The TS2250 also supports Microsoft Windows, HP-UX, Oracle Solaris, and UNIX.

There are two options for host connectivity:

SAS connectivity only	The two ports per drive are available to improve availability and ease of attachment. The Ultrium 6 SAS drive attempts to connect at 6 Gbps, but automatically negotiates down to 3 Gbps or even 1.5 Gbps if the system it is connected to cannot support 6 Gbps or has problems on the physical connection. Expander use is not supported.
SAS and USB connectivity	A single SAS and USB port is provided. The single-port SAS connector provides the same 6Gbps connectivity as the dual port, while the USB host interface supports USB 3.0 connectivity and can negotiate a Super Speed transfer rate. It also supports USB 2.0 connectivity at the slower transfer rates. The USB interface automatically negotiates speed. There are no configurable topologies, so no feature switches associated with USB. The tape drive with SAS or USB ports requires a device driver for USB 3.0 operation.

The TS2250 can read and write to Ultrium 5 and Ultrium 4 cartridges and is read compatible with Ultrium 4 data cartridges. The Ultrium 5 tape drive is encryption-capable and supports application managed encryption.

IBM LTFS Standalone Drive Edition (LTFS SDE) software is included with each TS2250 tape drive. LTFS uses LTO-5 tape drive partitioning. It enables a self-describing tape file format and to deliver an easy tape storage and distribution solution without the use of more database applications. Customers of IBM LTFS software are those who require a standard tape cartridge format at a low cost and use stand-alone IBM LTO-5 or LTO-6 tape drives.

The enclosure width allows two TS2250 storage units to be mounted side by side in a 19-inch IBM server rack mount shelf kit requiring two EIA units (2U) of rack space.

The TS2250 tape drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4 inch (QIC), 4 mm (DAT), 8 mm, or older LTO generation tape drives.

There are no unique power supply requirements. The TS2260 tape drive can attach to 100V to 125V power supplies at 60Hz or 200V to 240V supplies at 50 Hz AC.

IBM LTO Ultrium 5 Half-High tape drives have an internal buffer of 256 Megabytes.

Figure 2-27 shows a TS2250 tape drive.



Figure 2-27 IBM TS2250 Ultrium 5 Half-High tape drive

IBM LTO Ultrium 5 library drives

The library-installable Ultrium 5 tape drives can read and write to Ultrium 5 and Ultrium4 cartridges, and are read compatible with Ultrium 3 data cartridges.

The LTO Ultrium 5 tape drives support data encryption on the base drive with Ultrium 5 or Ultrium 4 media. System Managed and Library Managed Encryption and associated IBM Security Key Lifecycle Manager access are all available as a chargeable licensed key, Transparent LTO Encryption (feature code 5901 for TS2900, feature code 5900 for TS3100 or 3200, and feature code 1604 for TS3500 libraries). IBM Security Key Lifecycle Manager is required with this feature.

The Ultrium 6 and Ultrium 5 drives support media partitioning and the use of the IBM Linear Tape File System Library Edition (LTFS LE) and LTFS EE if installed in a supported library.

For more information about LTFS, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

For more information about LTFS EE, see *IBM Linear Tape File System Enterprise Edition V1.1.1.2 Installation and Configuration Guide, SG24-8143.*

IBM LTO Ultrium 5 Full-High library drives

IBM LTO Ultrium 5 Full-High (4 EIA units high) drives are available for use in the TS3100, TS3200, TS3310, and TS3500 libraries. These drives are specified and ordered with the following libraries:

- The TS3100 library can accommodate one Ultrium 5 SAS or FC Full-High tape drive.
- The TS3200 library can accommodate two Ultrium 5 SAS or FC Full-High tape drives.
- The TS3310 base L5B unit can accommodate two Ultrium 5 FC Full-High tape drives.
- The TS3310 optional E9U expansion unit can accommodate four Ultrium 5 FC Full-High tape drives.
- The TS3500 libraries can accommodate up to 192 TS1050 drives depending on their base and expansion frame configuration.
- The TS4500 libraries can accommodate up to 60 TS1050 drives depending on their base and expansion frame configuration

IBM LTO Ultrium 5 Full-High tape drives have an internal buffer of 512 Megabytes.

IBM LTO Ultrium 5 Half-High library drives

IBM LTO Ultrium 5 Half-High (2 EIA units high) drives are available for use in the TS2900, TS3100 and TS3200 libraries. These drives are specified and ordered with the following libraries:

- The TS2900 Autoloader can accommodate one Ultrium 5 SAS Half-High tape drive.
- The TS3100 library can accommodate two Ultrium 5 SAS or FC Half-High tape drive.
- The TS3200 library can accommodate four Ultrium 5 SAS or FC Half-High tape drives.

IBM LTO Ultrium 5 Half-High tape drives have an internal buffer of 256 Megabytes.

2.6 IBM LTO Ultrium 4 tape drives

The IBM LTO Ultrium 4 drives were announced in 2007. The IBM LTO Ultrium 4 tape drive is a high-performance, high-capacity data storage device that backs up and restores open systems applications. The drive can be integrated into an enclosure, such as a desktop unit, tape autoloader, or tape library. It is the fourth generation in the Ultrium series of products and is available with a Small Computer Systems Interface (SCSI LVD), Fibre Channel interface (FC), or serial-attached SCSI interface (SAS).

The Version 1 (V1) Ultrium 4 drive is a Full-High drive that still supports the SCSI LVD connection and 3 Gbps SAS and 4 Gbps FC options. The later Half-High Version 2 (V2) drive is based on the improved Ultrium 5 technology and provides faster 6 Gbps SAS and 8 Gbps FC attachment. When this was written, the Version 1 Ultrium 4 drives were still available for ordering in the TS3100, TS3200, and TS3310 libraries.

Ultrium 4 tape drive features at a glance

The LTO Generation 4 tape drive range has the following characteristics:

- Native data transfer rate of up to 120 MBps
- Compressed data transfer rate of up to 240 MBps
- LTO Ultrium 4 data and WORM tape cartridge native physical capacity of up to 800 GB
- Ultra 160 Low Voltage Differential (LVD) SCSI option using HD68 connector (V1 drive)
- 4 Gbps Fibre Channel attachment option (V1 drive)
- 3 Gbps SAS dual port attachment option (V1 drive)
- 8 Gbps Fibre Channel attachment option (V2 Half-High drive)
- 6 Gbps SAS dual port attachment option (V2 Half-High drive)
- 256 MB internal data buffer
- Application-managed encryption support
- System-managed and Library-Managed encryption support for non-stand-alone drives
- 8 KB cartridge memory with Ultrium 4 media

Compatibility

In addition to reading and writing to LTO Ultrium 4 tape cartridges, the Ultrium 4 tape drives can read and write to LTO Ultrium 3 cartridges and read LTO Ultrium 2 cartridges. It cannot read LTO Ultrium 1 cartridges.

The drive also writes to tapes that can be read by other licensed LTO Ultrium 4 drives. In addition to the use of the IBM LTO Ultrium Data Cartridge with up to 800 GB capacity, the drive offers read/write capability for certified LTO Ultrium 4 tape cartridges.

Table 2-13 shows the native data transfer rate when a data cartridge of another generation is processed.

Table 2-13 Native data transfer rate with various media

	Generation 4 media	Generation 3 media	Generation 2 media
Supported methods of operating	Read/write	Read/write	Read only
Native data rate SCSI (MBps)	120	80	35
Native date rate SAS (MBps)	120	80	35
Native data rate Fibre Channel (MBps)	120	80	35

Connectivity

The LTO Ultrium 4 tape drive family offers high capacity, performance, and technology for the midrange open systems environment. These drives offer the following connection types:

- Full-High V1 drives:
  - Ultra 160 Low Voltage Differential (LVD) SCSI using HD68 connector (not on TS1040)
  - 4 Gbps Fibre Channel using LC connector (not in TS2340 stand-alone drive)
  - 3 Gbps SAS attachment (not on TS1040)
- Half-High V2 drives:
  - 6 Gbps SAS attachment
  - 8 Gbps Fibre Channel - single port (only in TS3100 and TS3200 libraries)

IBM Ultrium drives can be connected to many different types of servers. For a list of server interface cards or Host-Bus-Adapters (HBAs) that are supported with the Ultrium drives, see this website:

http://www.ibm.com/systems/support/storage/ssic

Performance

The LTO Ultrium 4 tape drive uses 896 data tracks to read and write to Ultrium 4 tape. These tracks are grouped in five servo bands. Like the Ultrium 5 drives, the high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

The native data transfer rate for Ultrium 4 tape drives is 120 MBps. Compressed data rates can reach 240 MBps. IBM advises the use of the IBM TotalStorage LTO Ultrium 4 800 GB data cartridge, which provides up to 1600 GB of storage with a 2:1 compression ratio.

Speed matching

To improve the performance of the LTO Ultrium 4 tape drive, the tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the HBA of the server. The LTO Ultrium 4 tape drive negotiates with the HBA of the server to set up a speed with the best performance.

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces backhitching. *Backhitching* is a condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive. The Ultrium 4 tape drive has a 256 MB internal data buffer compared to a 128 MB internal data buffer in the Ultrium 3 tape drive.

For LTO-4 Full-High (FH) and version 1 Half-High (HH), the speed matching data rate is shown in Table 2-14.

Table 2-14 LTO-4 FH and version 1 HH drives

Performance parameters	Generation 4 media	Generation 3 media	Generation 2 media
Speed matching data rates MBps	120 103 84 66 48 40 30	80 70 60 50 40 30	30 26 22 19 15

For LTO-4 version 2 Half-High (HH), the speed-matching data rate is shown in Table 2-15.

Table 2-15 LTO-4 version 2 HH tape drive

Performance parameters	Generation 4 media	Generation 3 media	Generation 2 media
Speed matching data rates MBps	120.0 113.1 106.1 99.2 92.3 85.3 78.6 71.4 64.6 57.6 50.8 43.8 36.9 30.5	80.0 76.1 72.3 68.4 64.6 60.8 56.9 53.1 49.2 45.4 41.5 37.7 33.8 30.0	35.0 33.7 32.3 31.0 29.6 28.3 26.9 25.6 24.2 22.9 21.5 20.2 18.8 17.5

Encryption

The IBM LTO Ultrium 4 drive (including the TS1040) were the first tape drives within the IBM LTO tape family to support tape encryption. The LTO Ultrium 4 tape drive family supports application-managed tape encryption at no charge on the SAS and Fibre Channel tape drives. In case of library use, system-managed tape encryption and library-managed tape encryption are supported with the Transparent LTO Encryption features (FC5901). IBM Security Key Lifecycle Manager is required for encryption key management with LTO Ultrium 6 Drives.

Servo and track layout technology

Ultrium 4 technology uses 896 data tracks compared to the 704 data tracks in Ultrium 3 that are used to read and write data to the data cartridge. These tracks are grouped into five servo bands, as described in “Servo tracks” on page 47. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and to improve data throughput with damaged media in less-than-optimal shock and vibration environments.

Magneto-resistive head design

Magneto-resistive head design that uses flat lap head technology in magneto-resistive heads for Ultrium 4 helps minimize contact, debris accumulation, and wear on the tape as it moves over the read/write heads.

Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism guides the tape along the tape path in the LTO Ultrium 4 tape drive. This method uses the surface of the tape (rather than the edges) to control tape motion. This method helps to reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

The Statistical Analysis Reporting System

The customer-centric Statistical Analysis and Reporting System (SARS) provides information that reflects the current and overall health of the drive and any media that was recently used within the Ultrium 4 drives. The SARS can be used directly by the host or a subsystem to monitor the systemic operational characteristics of the drives and media.

2.6.1 The IBM LTO Ultrium 4 tape drive range

The IBM LTO Ultrium 4 drive range is a mix of Half-High and Full-High stand-alone and library-installable drives. This offers a high-performance, high-capacity data storage devices that back up and restore open systems applications. The drive can be integrated into an enclosure, such as a desktop unit, tape autoloader, or tape library. The IBM LTO Ultrium 4 drive range consists of the following components:

- TS2340 (3580 L43 for SCSI or 3580 S43 for 3 Gbps SAS) Full-High stand-alone drive
- TS2240 (3580 Model H4V) 6 Gbps SAS Half-High stand-alone drive
- Ultrium 4 SAS Half-High tape drive sled inside a TS2900 tape autoloader
- Ultrium 4 SCSI LVD Full-High tape drive sled inside a TS3100 tape library
- Ultrium 4 3 Gbps SAS Full-High tape drive sled inside a TS3100 tape library
- Ultrium 4 4 Gbps FC Full-High tape drive sled inside a TS3100 tape library
- Ultrium 4 6 Gbps SAS V2 Half-High tape drive sled inside a TS3100 tape library
- Ultrium 4 8 Gbps FC V2 Half-High tape drive sled inside a TS3100 tape library
- Ultrium 4 SCSI LVD Full-High tape drive sled inside a TS3200 tape library
- Ultrium 4 3 Gbps SAS Full-High tape drive sled inside a TS3200 tape library
- Ultrium 4 4 Gbps FC Full-High tape drive sled inside a TS3200 tape library
- Ultrium 4 6 Gbps SAS V2 Half-High tape drive sled inside a TS3200 tape library
- Ultrium 4 8 Gbps FC V2 Half-High tape drive sled inside a TS3200 tape library
- Ultrium 4 SCSI LVD Full-High tape drive sled inside a TS3310 tape library
- Ultrium 4 3 Gbps SAS Full-High tape drive sled inside a TS3310 tape library
- Ultrium 4 4 Gbps FC Full-High tape drive sled inside a TS3310 tape library
- TS1040 (3588 F4A) FC Full-High tape drive sled within a TS3500 tape library

Important: Extra care should be taken when specifying Ultrium 4 drives in libraries, because many different drive and interface options are available.

IBM TS2340 (3580 L43/S43) tape drive

IBM TS2340 tape drive model L43/S43 (3580 L43/S43) is an external Full-High (4 EIA units high) stand-alone or rack mountable unit that offers high capacity and performance for the midrange systems environment.

The TS2340 Model L43/S43 tape drive uses an LVD SCSI or 3 Gbps SAS interface for connection to a wide spectrum of system servers.

The TS2340 can read and write to Ultrium 4 and Ultrium 3 cartridges and is read compatible with Ultrium 2 data cartridges. The Ultrium 4 tape drive is encryption-capable and supports application managed encryption.

The enclosure width allows two TS2340 storage units to be mounted side by side in a 19-inch IBM server rack mount shelf kit requiring four EIA units (4U) of rack space.

The TS2340 tape drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4 inch (QIC), 4 mm (DAT), 8 mm, or older LTO generation tape drives.

There are no unique power supply requirements. The TS2340 tape drive can attach to 100V to 125V power supplies at 60Hz or 200V to 240V supplies at 50 Hz AC.

IBM LTO Ultrium 4 Full-High tape drives have an internal buffer of 256 MBs.

Figure 2-28 shows a TS2340 tape drive.



Figure 2-28 LTO Ultrium 4 TS2340 tape drive

IBM TS2240 (3580 H4V) tape drive H4S

IBM TS2240 tape drive model H4V (3580 H4V) is an external Half-High (2 EIA units high) stand-alone or rack mountable unit that offers high capacity and performance for the midrange systems environment.

The TS2240 Model H4V tape drive uses a 6 Gbps dual port SAS interface for connection to a wide spectrum of system servers.

The TS2240 can read and write to Ultrium 4 and Ultrium 3 cartridges and is read compatible with Ultrium 2 data cartridges. The Ultrium 4 tape drive is encryption-capable and supports application managed encryption.

The enclosure width allows two TS2240 H4V storage units to be mounted side by side in a 19-inch IBM server rack mount shelf kit requiring two EIA units (2U) of rack space.

The TS2240 tape drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4 inch (QIC), 4 mm (DAT), 8 mm, or older LTO generation tape drives.

There are no unique power supply requirements. The TS2260 tape drive can attach to 100V to 125V power supplies at 60Hz or 200V to 240V supplies at 50 Hz AC.

IBM LTO Ultrium 4 Half-High tape drives have an internal buffer of 256 MBs.

Figure 2-29 on page 97 shows a TS2240 tape drive.



Figure 2-29 TS2240 tape drive

Figure 2-30 shows the difference in size of the previous 3580 H4S model compared to the newer 3580 H4V model.

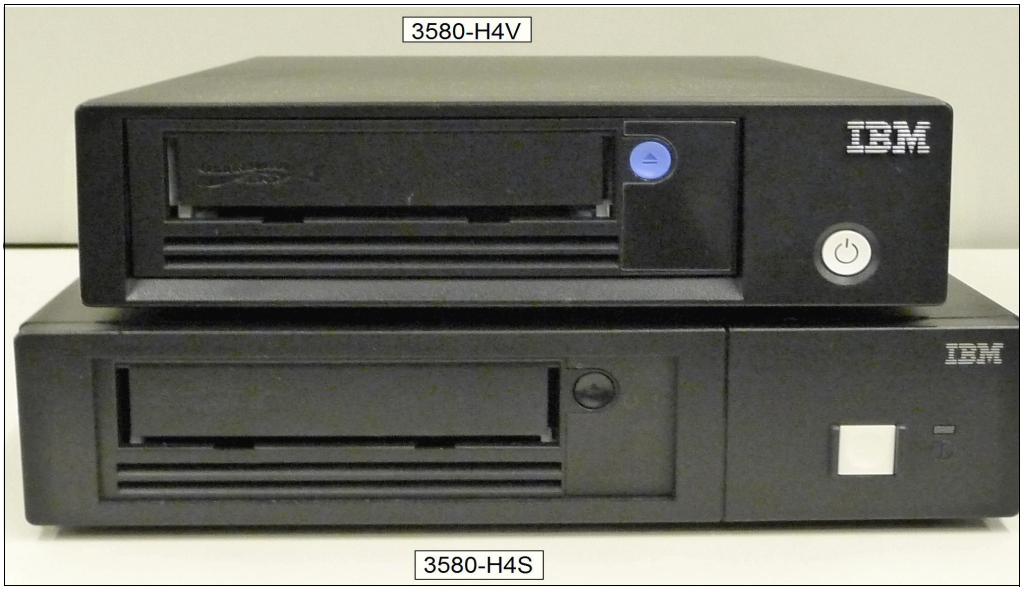


Figure 2-30 3580 H4V and H4S comparison

IBM LTO Ultrium 4 library drives

The library-installable Ultrium 4 tape drives can read and write to Ultrium 4 and Ultrium 3 cartridges, and are read compatible with Ultrium 2 data cartridges.

The LTO Ultrium 4 tape drives support data encryption on the base drive with Ultrium 4 media. System Managed and Library Managed Encryption and associated IBM Security Key Lifecycle Manager access are all available as a chargeable licensed key and Transparent LTO Encryption (feature code 5901 for TS2900, feature code 5900 for TS3100 or 3200, and feature code 1604 for TS3500 libraries). IBM Security Key Lifecycle Manager is required with this feature.

Extra care should be taken when Ultrium 4 drives are specified in libraries because so many drive and interface options are available.

IBM LTO Ultrium 4 Full-High library drives

IBM LTO Ultrium 4 Full-High (4 EIA units high) drives are available for use in the TS3100, TS3200, TS3310, and TS3500 libraries. These drives are specified and ordered with the following libraries:

- The TS3100 library can accommodate one Ultrium 4 SCSI, SAS, or FC Full-High tape drive.
- The TS3200 library can accommodate two Ultrium 4 SCSI, SAS or FC Full-High tape drives.
- The TS3310 base L5B unit can accommodate two Ultrium 4 SCSI, SAS or FC Full-High tape drives.
- The TS3310 optional E9U expansion unit can accommodate four Ultrium 4 SCSI, SAS or FC Full-High tape drives.
- The TS3500 libraries can accommodate up to 192 TS1050 Full-High FC Drives depending on their base and expansion frame configuration.

IBM LTO Ultrium 4 Full-High tape drives have an internal buffer of 256 MBs.

IBM LTO Ultrium 4 Half-High library drives

IBM LTO Ultrium 4 Half-High (2 EIA units high) V2 drives are available for use in the TS2900, TS3100 and TS3200 libraries. These drives are specified and ordered with the following libraries:

- The TS2900 Autoloader can accommodate one Ultrium 4 SAS Half-High tape drive
- The TS3100 library can accommodate two Ultrium 4 SAS or FC Half-High tape drive
- The TS3200 library can accommodate four Ultrium 4 SAS or FC Half-High tape drives

IBM LTO Ultrium 4 Half-High tape drives have an internal buffer of 256 megabytes.

Important: Take extra care when Ultrium 4 drives are specified in libraries, because many different drive and interface options are available.

2.6.2 The IBM LTO Ultrium family of tape drives and libraries

The IBM LTO Ultrium family of tape drives and libraries (as shown in Figure 2-31) consists of the product offerings that range from a stand-alone unit to a highly scalable, automated library.



Figure 2-31 IBM tape libraries, tape autoloader, and tape drives

The TS4500 tape library, the newest addition to the IBM family of tape products, shows the minimum and maximum configurations in Figure 2-32.



Figure 2-32 Minimum and maximum TS4500 tape library configurations

The product offerings are all based on a common tape drive subassembly that is packaged in various robotic and stand-alone environments. As shown on the right side of Figure 2-31 on page 99, the following tape drives and libraries are available:

- The IBM TS2260 tape drive is an external stand-alone or rack-mountable (optional) unit for the family of IBM LTO Ultrium Tape products. It features the LTO Ultrium 6 Half-High tape drive.
- The IBM TS2900 tape autoloader is an external stand-alone or rack-mountable unit in the family of IBM LTO Ultrium Tape products. When it is mounted in a rack, it occupies one unit of the rack. It features one LTO Ultrium Half-High tape drive.
- The IBM TS2360 tape drive is an external stand-alone or rack-mountable (optional) unit for the family of IBM LTO Ultrium Tape products. It features the LTO Ultrium 6 Full-High tape drive.
- The IBM TS3100 tape library is a desktop or rack-mountable single drive unit that can hold up to 24 cartridges. A robotic system moves the cartridges to and from the drive. When it is mounted in a rack, it occupies two units of the rack. It features up to two LTO Ultrium Half-High tape drives or one LTO Ultrium Full-High tape drive.
- The IBM TS3200 tape library is a desktop or rack-mountable single or dual drive unit that can hold up to 48 cartridges. It has a three slot I/O station that must be shared when logical libraries are configured. When it is mounted in a rack, it occupies four units of the rack. It features up to four LTO Ultrium Half-High tape drives or up to two LTO Ultrium Full-High tape drives.
- The IBM TS3310 tape library is highly modular and vertically expandable. The smallest configuration includes a base module with one to two LTO Ultrium Full-High tape drives, 52.5 TB of native tape storage (35 slots), and 6 I/O slots. This tape library can be upgraded to a fully configured rack-mounted library 41U high. It will have up to 18 LTO Ultrium Full-High tape drives, over 603 TB of native tape storage (409 slots), and up to 54 I/O slots.

- The IBM TS3500 tape library is shown on the left side of Figure 2-31 on page 99. This tape library is a larger modular enterprise class library with the potential to house a maximum of 192 IBM LTO or IBM 3592 tape drives in as many as 16 frames. The library also can be ordered with a dual accessor model option to help increase mount performance and overall system reliability and availability. The new LTO-6 technology can greatly increase library capacity compared to previous LTO technology (in the same foot print) at a typically lower storage cost. A TS3500 tape library with High Density (HD) frames can store over 50 petabytes (PB) of uncompressed data or 125 PB at a 2.5:1 compression ratio. With the release of the TS3500 tape library Shuttle Complex configuration that supports over 300,000 LTO cartridges, an astounding capacity value of over 450 PB can be reached.
- The IBM TS4500 is a highly scalable, stand-alone tape library that provides high-density tape storage and high-performance, automated tape handling for open systems environments. An individual library consists of one base frame and up to three expansion frames and can include up to 60 tape drives and more than 4,500 tape cartridges, as shown in Figure 2-32 on page 100.

  The TS4500 tape library provides the following capabilities:

  - All of the frames include high-density (HD) slot technology
  - Additional frame models can be placed in any active position so that the library can grow from both the right side and the left side of the first L frame
  - Integrated management console (IMC)
  - New user interface for improved usability
  - Updated control system
  - Input/output (I/O) magazine to allow individual cartridge handling to be performed independently of the library
  - Top-rack space to house extra tape solution components within the library footprint
  - Support for HD2-compatible models of the TS1150 (3592 EH8), TS1140 (3592 EH7), LTO 5 (3588 F5C), and LTO 6 (3588 F6C) tape drives

  The TS4500 tape library is available with several tape drives, frame models, and feature options, to meet your specific needs. Additional features of the TS4500 tape library are highlighted in the following list:

  - Advanced Library Management System (ALMS)
  - Ability to attach multiple simultaneous heterogeneous servers
  - Remote management with the TS4500 management GUI or the TS4500 command line
  - Command-line interface (CLI)
  - Remote monitoring using Simple Network Management Protocol (SNMP), email, or syslog
  - Multipath architecture
  - Drive and media exception reporting
  - In-depth reporting using the Tape System Reporter (TSR)
  - Host-based path failover
  - Up to 144 I/O slots (36 I/O slots standard for LTO libraries and 32 I/O slots standard for 3592 libraries)

  For more information about the TS4500 tape library, see the IBM Redbooks publication titled *IBM TS4500 Tape Library Guide*, SG24-8235.

2.6.3 Multipath architecture

The patented multipath architecture is an IBM unique feature. The TS3100, TS3200, TS3310, TS3500, and TS4500 tape libraries implemented the second generation of the architecture. It uses the SCSI-3 Move Media command set that is featured in midrange and open libraries. The multipath architecture removes the need for a dedicated server plus middleware to control the use of a library by multiple hosts that are using various operating systems because each drive has its own path to the control unit.

Conventional tape libraries use a dedicated host port to communicate with the library; for example, for sending mount request commands. IBM LTO tape libraries use the same path to communicate with the drives and the library controller, as shown in Figure 2-33. This path is not one dedicated path; it might be any path to any tape drive.

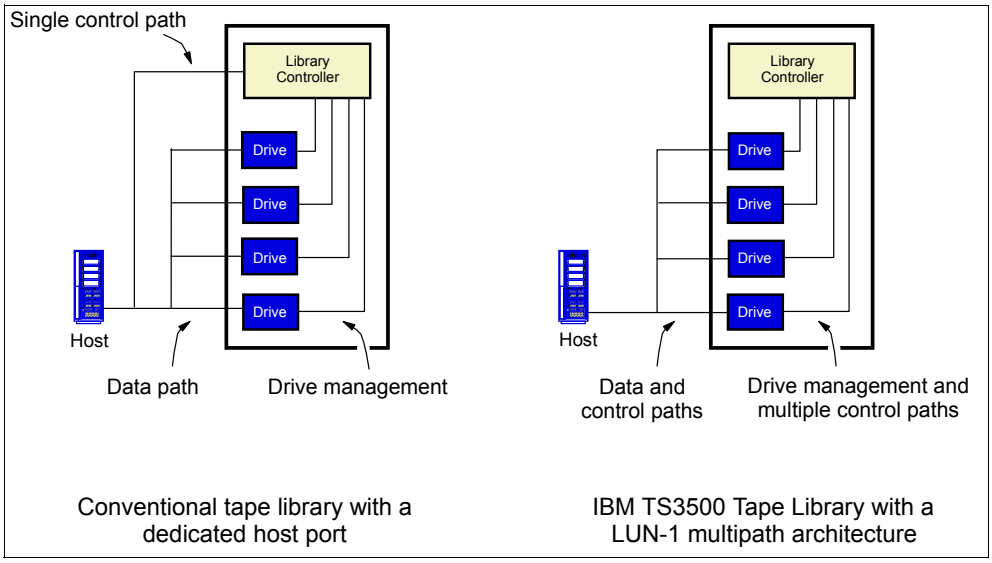


Figure 2-33 Conventional tape library compared to multipath architecture

For conventional tape libraries, the control path is a single point of failure. By contrast, the IBM LTO tape libraries offer as many control paths as there are drives installed in the library. Therefore, if an individual control path failure occurs, the library communication can be over different, redundant control paths.

As shown in Figure 2-34, if one path to a drive is broken because of a defective switch port, cable, or HBA, communication to the library controller can occur by using one of the other available paths. With automatic Control Path Failover, this design constitutes a unique high-availability option.

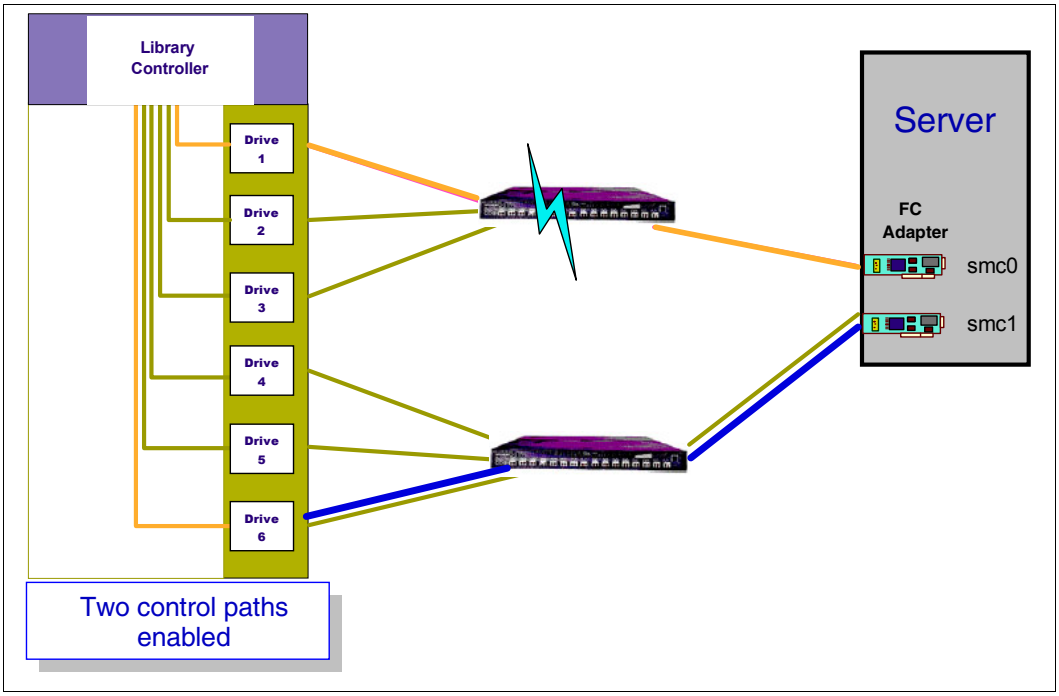


Figure 2-34 Redundant control paths to the library controller

In addition to the redundant control path, multipath architecture offers the benefit of built-in partitioning. With the partitioning feature of the IBM LTO libraries, the physical library can be divided into several smaller logical libraries, which are independent of each other. The maximum number of logical libraries varies by model type. A logical library must contain at least one tape drive and cartridge cell and can consist of more than one tape drive that shares the same cartridge cells.

Multiple heterogeneous hosts can share the library with this partitioning option. Each logical library has its own drives, cartridges, and control paths. Because of barriers between the logical libraries, cartridges cannot be moved from one logical library to another.

Figure 2-35 shows three logical libraries, with two drives each and several cartridge storage slots that are dedicated to each of the heterogeneous servers.

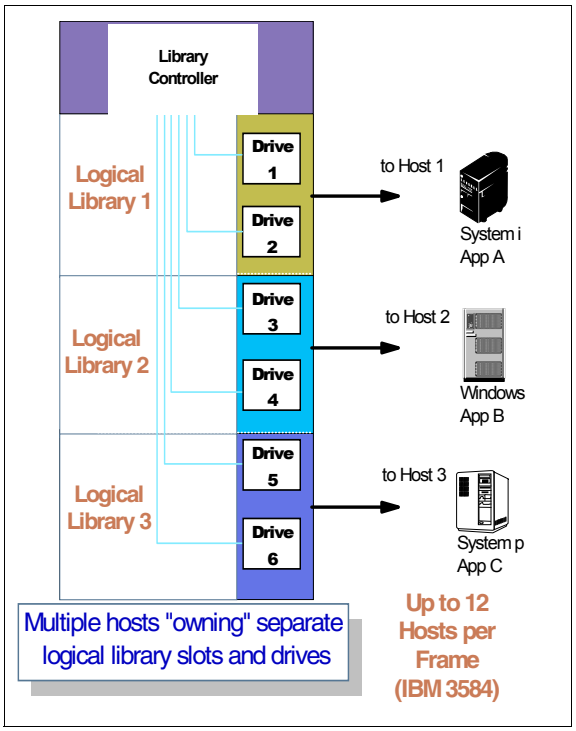


Figure 2-35 IBM LTO tape library partitioned into three logical libraries

2.6.4 Next-generation multipath architecture

The Advanced Library Management System is an optional extension to the IBM patented multipath architecture. The multipath architecture virtualized the library accessor. This architecture enabled a library to be partitioned into multiple logical libraries and allowed a single library accessor to be used by multiple host computers in a transparent manner. The ALMS virtualizes the SCSI element address for storage slots, I/O slots, and drives. ALMS provides enhanced automation functionality, such as dynamic partitioning, including storage slot pooling and flexible drive assignment. Tape drives can be assigned to any logical library and to multiple logical libraries by using a web browser-based user interface. Logical libraries can be added, deleted, or easily changed non-disruptively. Storage capacity can be changed without any impact to host applications.

ALMS is a feature with the TS3500 tape library. For more information, see 10.6, “Advanced Library Management System” on page 346.

Note: Advanced Library Management System (ALMS), which comes standard on the TS4500, always shows as installed. For more information see the Redbooks publication titled *IBM TS4500 Tape Library Guide*, SG24-8235.

3

IBM TS1100 tape drives

This chapter describes the TS1100 tape drive family, its common characteristics, the differences between the four generations, and the IBM 3592 media characteristics. This chapter focuses on these models:

- IBM TS1150 tape drive (3592 Model E08 and Model EH8)
- IBM TS1140 tape drive (3592 Model E07 and Model EH7)
- IBM TS1130 tape drive (3592 Model E06 and Model EU6)
- IBM TS1120 tape drive (3592 Model E05)
- IBM TotalStorage Enterprise 3592 Model J1A tape drive

Important: The 3592 Model J1A and TS1120 (3592 Model E05) are withdrawn from marketing, but is still supported in various subsystems. As a result these drives are explained briefly here.

Note: TS1140 model EH7 and TS1150 model EH8 are functionally the same as TS1140 Model E07 and TS1150 model E08, but they are packaged for integration into a TS4500. These are discussed in detail in, *IBM TS4500 Tape Library Guide, SG24-8235.* We will only discuss models E07 and E08 in this chapter.

This chapter includes the following topics:

- IBM TS1100 tape drive family
- Common characteristics of the 3592 tape drive family
- Physical attachment
- Media
- IBM TS1150 tape drive
- IBM TS1140 tape drive
- IBM TS1130 tape drive
- IBM TS1120 tape drive
- IBM TotalStorage Enterprise tape drive 3592 Model J1A

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3.1 IBM TS1100 tape drive family

The IBM TS1120 (Machine Types 3592-E05), TS1130 (Machine Types 3592-E06 and 3592-EU6), TS1140 (Machine Type 3592-E07 and 3592-EH7), and TS1150 (Machine Type 3592-E08 and 3592-EH8) offer a design that is focused on high capacity, performance, and high reliability for storing mission-critical data. With the introduction of the first generation of the new family of tape drives, IBM advanced its high-end half-inch cartridge tape technology to a new level.

The 3592 family was enlarged and improved with the addition of the IBM TS1150, 3592 Model E08 and Model EH8 tape drives. The TS1150 is the fifth generation of the 3592 tape drive family, which provides the unsurpassed capacity of 10 TB of uncompressed data on a single tape plus improved levels of performance.

3.1.1 The 1 TB background

On 5 April 2002, IBM achieved an unprecedented feat at the time when 1 TB of data was recorded, without compression, to a half-inch format tape. This record was a technological accomplishment that set the foundation for the 3592 tape drive family.

In 2006 IBM further demonstrated their technology leadership by the recording of 8 TB to a half-inch format tape, and in 2010 demonstrated recording 35 TB of uncompressed data to a half-inch format tape.

In 2014 the capacity of tape was demonstrated by IBM and FujiFilm announcing that their researchers have broken the world record in the amount of data that can be stored per square inch on Linear Tape-Open (LTO) cartridge.

IBM's demonstrations showed that FujiFilm's "double-coated" tape could store 85.9 billion bits per square inch on areal data density on linear magnetic particulate tape. With this density, a standard tape cartridge could store 154 terabytes of uncompressed data, which would be 62 times better than existing cartridges IBM used the evolutionary progression of technology building blocks that were set in place over the preceding years to make these advances. An enterprise tape drive roadmap was laid out to ultimately reach and far exceed the 1 TB in native cartridge capacity within 3592 tape drive generations.

http://www.ibm.com/press/us/en/pressrelease/43945.wss

The 3592 Model J1A became the first tape drive generation of the Enterprise Tape family. It enabled the storage of 300 GB of data to a cartridge (900 GB with 3:1 compressible data).

The same cartridges can be reused by the second generation of 3592 tape drives. The TS1120 Model E05, is able to store even more data than before. Using the JA media it is possible to store without compression 500 GB of data, and with the high capacity JB cartridge 700 GB of data.

With the third generation of IBM 3592 tape drive, it was possible to store 640 GB on JA media and 1TB on the JB media. This achieved the first milestone where IBM delivered a 1 TB tape technology to the market.

The fourth generation of 3592, the IBM TS1140 model E07, IBM once again advanced tape capacity to a new level. The TS1140 is capable of storing over 1.6 TB of data on the JB cartridge type and 4 TB of data on the JC cartridge type.

The fifth generation of 3592, the IBM TS1150 model E08, IBM has once again demonstrated IBM commitment to tape technology by taking tape capacity to a new level. The TS1150 can store 7 TB of data on the JC cartridge type and 10 TB of data on the new advanced JD cartridge type. IBM kept its documented promise in the roadmap for 3592 tape drives and provided a 10 TB tape drive.

3.1.2 Nomenclature

Because of many common considerations for the TS1120, TS1130, TS1140, and TS1150 tape drives, and to make reading more convenient the following names are used in the following chapters.

Tape drives

- 3592 is used, referring to all models
- 3592-J1A is used for the first 3592 generation
- TS1120 is used for the 3592 E05 tape drive
- TS1130 is used for the 3592 E06 tape drive
- TS1140 is used for the 3592 E07 tape drive
- TS1150 is used for the 3592 E08 tape drive

Media format

- 3592 is used, referring to all 3592 media formats
- J1A is used for the first 3592 J1A media format
- E05 is used for the 3592 E05 media format
- E06 is used for the 3592 E06 media format
- E07 is used for the 3592 E07 media format
- E08 is used for the 3592 E08 media format

Note: TS1150 denotes the product name, and 3592 E08 denotes the machine type and model.

3.2 Common characteristics of the 3592 tape drive family

The 3592 tape drive family has the following common characteristics, which are described in this section:

- Technology enhancements
- Reliability and availability improvements
- Features for performance and capacity
- Media that can be reused by the next generations of drives

3.2.1 Technology enhancements

The 3592 tape drive family includes the following key features:

- Virtual backhitch, which is the optimum adaptive format and algorithm for improved start-and-stop write performance. For more information, see “Virtual backhitch (nonvolatile caching)” on page 112.
- High performance and robust dual microprocessor architecture. One microprocessor operates the host attachment interface (which is running what is proven 3590 host attach microcode). The other microprocessor focuses strictly on writing data and reading data from tape. Each microprocessor resets the other microprocessor to act as a fail-safe.
- Statistical Analysis Recording System (SARS) algorithm with extended mount count.

- Fast random access performance when operating on any of the Short Length Cartridge (SLC) types.
- Support of an enhanced capacity scaling and segmentation format when operating on the full-length, read/write cartridge type JA, JB, JC, and JD which enables fast locate and read times.
- Streaming Lossless Data Compression (SLDC) algorithm, which is an enhancement of the Lempel-Ziv class 1 (LZ-1) data compression algorithm.
- The new JD, JZ, and JL media types contain 16KB cartridge memory, increased from the 8KB contained in JC and JB media types and 4Kb on JA, JW, JR, and JJ media types.

3.2.2 Recording format

The IBM 3592 tape drive uses an advanced interleaved bidirectional serpentine recording technique that writes 8, 16, or 32 (depending on the drive) data tracks at a time on a 3592 cartridge. The 3592 cartridge is a half-inch, advanced metal particle, dual layer tape. The tape layout consists of five servo bands (pre-recorded on the tape) and four data bands where the data is written, as shown in Figure 3-1. The servo bands provide location information to control the positioning of the head as it writes and reads data within the data band. For more information about this design, see “Servo tracks” on page 108.

As shown in Figure 3-1, the area between adjacent servo bands is a *data band*. The 3592 media has four data bands, each with a number of data tracks (128 - 288, which is different for each model).

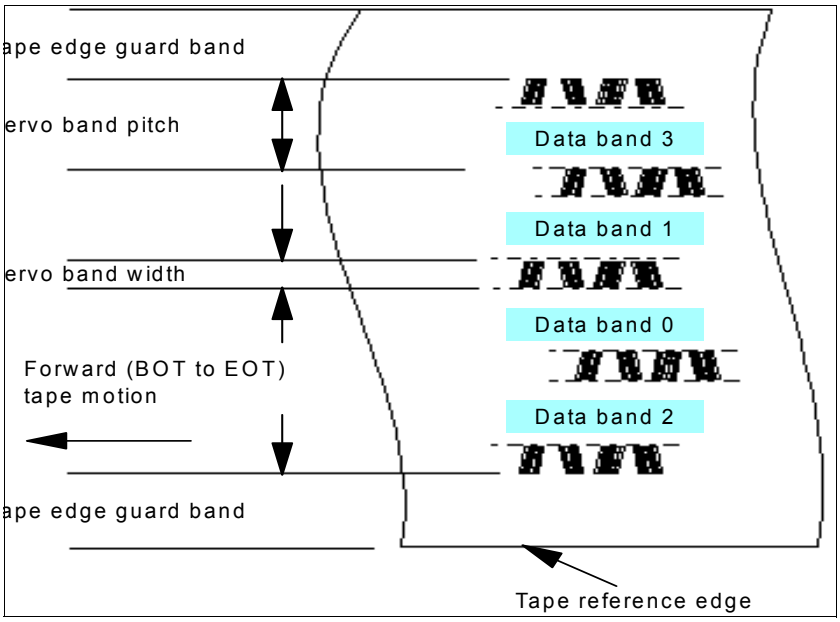


Figure 3-1 Layout of the servo and data bands on the 3592 media

Servo tracks

Servo tracks or bands help to ensure accurate positioning of the tape drive head over the data track so that the head does not stray onto an adjacent track. Servo tracks are necessary to support high-data densities on the tape where the tracks are extremely close together. The servo tracks are written at the time of cartridge manufacture, before the cartridge is usable for data storage and retrieval. Each tape write head has two *servo heads*, one servo head for each of the two *servo bands* that it spans.

Two servo bands are used simultaneously to provide two sources of servo information for increased accuracy. Control positions within the servo band are used to reposition the head to write forward and reverse wraps, within each of the four data bands. This timing-based servo technology can be finely tuned. It can support extremely high-track densities for future 3592 generations because more than eight positions can be defined within the same servo band, thus expanding the potential track densities.

In addition, there are significant advances in the tape coating process, which uses high-quality metal particle media.

3.2.3 Reliability and availability

The 3592 tape drive incorporates and expands on the high reliability and function of previous IBM drives that were developed over many years of experience. It builds on proven technologies to enhance and apply new techniques to ensure high reliability and availability.

Improved availability

Improved availability includes the following characteristics:

- Single field-replaceable unit (FRU)

  When a service call is placed, the IBM Service Support Representative (SSR) does not replace any parts or subassemblies inside the canister. The smaller drive unit means that for any failure within the drive, the IBM SSR exchanges the entire unit rather than performing lengthy diagnostics or component replacement in the field.

- Redundant, hot-pluggable power supplies

  In all configurations, the drives are seated in *cradles* that contain two power supplies. Each pair of power supplies can be used by one or two drives. One of these power supplies is sufficient to run both drives, and the second power supply is provided for redundancy.

- Retention of the Fibre Channel (FC) worldwide name ID during service action

  When a failed drive is exchanged, the attached hosts or storage area network (SAN) do not need to be re-configured to recognize a replacement drive. This function also eliminates any issues with SAN hosts finding incorrect addresses during a system reboot.

Advanced technology

Advanced technology includes the following characteristics:

- Robust loader mechanism

  The loader mechanism is suitable for the heavy-duty cycle use in mainframe systems. The leader block on the tape cartridge is replaced by a metal pin, which is enhanced over previous drive implementations for increased robustness.

- Elimination of drive pneumatics and mechanical adjustments

  The aerodynamic movement of the tape over the flat-lap head pulls the tape close to the head while the tape is moving and provides maximum efficiency in reading and writing. Because of the shape of the head, particles do not accumulate on the tape, which eliminates the possibility of debris contaminating the tape surface. Air-bearing heads effectively cushion the tape moving across the head. However, whenever the tape stops, it relaxes toward the head surface. The head has a two-stage actuator: one mechanism for moving to the required tape wrap and another finer actuator for adjustments to the track-following servo.

- Straighter and shorter tape path for better tape tracking

  Tape tracking is improved by using grooved rollers to provide surface-controlled guiding. This enhancement decreases potential wear or damage on the edges of the tape and, with the shorter tape path, decreases lateral movement.

- Speed matching to reduce backhitching (see 3.2.4, “Features designed for capacity and performance” on page 111)

  Buffering, speed matching, and virtual backhitch algorithms all serve to eliminate physical backhitching. They improve performance and reduce the wear on the drive mechanics caused by continually braking and reversing direction.

- Channel calibration to optimize performance and data integrity

  The drive uses individual read/write data channel calibration, which uses sophisticated techniques that were originally implemented in disk technology.

Enhanced service functions

The following service functions were enhanced:

- Enhanced SARS recording

  The tape drive uses the Statistical Analysis Recording System (SARS) to assist in isolating failures between media and hardware. The SARS uses the cartridge performance history that is saved in the cartridge memory module and the drive performance history that is kept in the drive flash. The cartridge memory is a serial Electronically Erasable Programmable Read-Only Memory (EEPROM), with read-only and rewritable areas, to determine the more likely cause of failure. The SARS can cause the drive to request a cleaner cartridge (based on use) to mark the media as degraded and to indicate that the hardware is degraded. SARS information is reported through the TapeAlert flags and through media information messages (MIMs) and service information messages (SIMs).

- Diagnostic information

  The drive maintains logs to assist engineering or service personnel. The logs are included in drive memory dumps and are accessible to service personnel in several ways, including through the hot-pluggable service panel. Memory dumps are maintained over Power On Reset (POR).

- More temperature and voltage sensors to improve error isolation

  The drive contains sensors and circuits to detect errors. A temperature sensor monitors the temperature of the drive electronics. Voltage sensors detect when the power supply is out of tolerance. Other error checks, such as tape velocity checks, read/write data integrity checks, and servo checks are performed by using circuitry and sensors. The drive microcode checks for logic errors to handle hardware-detected errors and to detect and report microcode-related errors.

- Drive status indicators and reliability, availability, and serviceability (RAS) functions on the library drive interface

  The drive provides indicators for FC status, whether the power is good, and faults. However, the drive hot-pluggable service panel is the key service tool to perform test procedures and interpret results. Many functions and information can now be accessed that were previously available only from this panel in the 3494 Library Manager interface, which is more convenient and accessible to clients and service personnel.

- Concurrent microcode update, with options to switch the new or old copy of drive code.

- Backup drive vital product data (VPD card) stored from the drive

  When a drive is replaced, the VPD can be quickly downloaded to the drive by using the backup, which reduces the time taken for repair or configuration.

- Functional microcode updates through the library manager broadcast

  The firmware (microcode) can be updated in the 3592 tape drive in several ways, and the update no longer requires a Field Microcode Replacement (FMR) tape. The firmware can be updated by using the following components:

  – FMR cartridge that contains the updated code
  – Host attachment (FC bus) by using the write buffer command or using ITDT
  – RS-422 port to the drive if supported by the library automation
  – Ethernet port (on TS1140 and TS1150 only)

- Preventive maintenance

  The 3592 tape drive requires no preventive maintenance beyond the use of the cleaning cartridge. The 3592 media cartridges require proper care and appropriate handling and shipping procedures.

3.2.4 Features designed for capacity and performance

As mentioned previously, the unique features and specifications of the 3592 make it a true enterprise tape drive in terms of performance and reliability. The following sections describe these industry leading features in greater detail.

Important: These features are generic for all 3592 drives. The TS1150 has other advanced features that are described in 3.5, “IBM TS1150 tape drive” on page 124.

Data buffer

The drive has a large data buffer with read-ahead buffer management that addresses the lowest band of data rates. It effectively collects more blocks of data in the buffer before writing to the drive at a higher speed. As a result of this data buffer, the drive stops and starts less often, which generally improves the overall performance and reliability of the drive and tape.

Speed matching

For medium data rates when they are operating from a host that cannot sustain the maximum 3592 data rate, the drive performs dynamic *speed matching*. The drive adjusts the native data rate of the drive as closely as possible to the net host data rate (after factoring out data compressibility). The 3592 drive operates at various speeds (between 6 and 13 speeds, depending on the drive that is used) when the 3592 format is read or written to in an attempt to match the effective host data rates. If the net host data rate is between two of the speed matching native data rates, the drive calculates at which of the two data rates to operate. Speed matching reduces the number of required backhitches. In some environments, the backhitch of the drive is masked by the data buffer of the drive. Therefore, the system throughput is not improved or reduced by speed matching.

Cartridge memory

Contained within the cartridge is the Cartridge Memory (CM), which is a passive, contactless silicon storage device that is physically a part of the cartridge. The CM is used to hold information about that specific cartridge, the media in the cartridge, and the data on the media.

3592 uses the same CM module as LTO media, with a capacity of 4 KiB, extended to 8 KiB on JB/JX media and JC/JY/JK media, enhanced to 16 KiB for JD or JZ media). The CM has been designed for 3592 to support the high-resolution tape directory feature and differs from the LTO specification. It supports the high-resolution tape directory feature (see “High-resolution tape directory” on page 112).

Communication between the drive and the cartridge memory occurs through a noncontact, passive radio frequency interface (RFI), which eliminates the need for physical connections to the cartridge for power or signals.

High-resolution tape directory

The 3592 drive maintains a tape directory structure with a higher granularity of information about the physical position of data blocks and file marks on the media. This feature gives the 3592 drive improved nominal and average access times for locate operations. Locate times are uniform. They are based on the position of the block or file mark on the tape independent of the uniformity of the block size or file mark distribution along the length of the tape. Therefore, the 3592 locate and space performance is targeted to be completely and individually dependent on the longitudinal position on tape of the target block or file mark.

Virtual backhitch (nonvolatile caching)

The 3592 stages write-data through an intermediate DRAM buffer on its way to tape. This buffer is volatile because it does not retain what is stored if power is lost. For streamed writes (or reads), this buffer yields considerably improved performance.

When streaming writes cease, a typical pre-3592 tape drive halts the tape and repositions it directly upstream of where the writing ended. From this action, subsequently received data can be written immediately following the previously written data. This method eliminates the waste of the considerable length of tape. Substantial lengths of unwritten tape can significantly reduce capacity. Here, a backhitch (reverse) by typical tape drives is used to eliminate this capacity loss following a write to tape.

Nonvolatile caching (NVC) is a 3592 feature that can help greatly improve write performance through backhitch reduction. This system temporarily reserves portions of physical tape for cache areas. Data that is received from the host is written to the volatile buffer as usual and to nonvolatile tape cache areas with the exception that no backhitch is necessary when temporary copies are written to cache areas of tape. This temporary capacity loss is easily recouped.

The data is written to temporary cache areas and is not released in the volatile buffer, but instead it accumulates. This accumulation continues until the buffer is nearly full. At this time, the accumulated data in the buffer is rewritten through a streamed write to the standard area of tape. When the rewrite is complete, the temporary cache areas of tape are released so that they can be overwritten. To significantly improve the average write throughput to tape, temporary copies can be written to the cache areas of tape without backhitching until the buffer is nearly full. Then, a rewrite of the data can be streamed to the standard area of tape.

Aside from the improved write throughput performance, the second effect of NVC writing is to recover the capacity lost by the standard writing technique. Data that is received between synchronization events fills containers of data to be written to tape called *device blocks* or *data sets*. The standard writing technique calls for padding the last partially filled data set. This padding on average amounts to half the size of the last data set. Given the large data set sizes of modern tape drives, this loss can be substantial.

The streaming rewrite of the data that is accumulated in a buffer causes nearly all data sets written to a standard area of tape to be written in full, which is known as *data set packing*.

Writing in NVC mode is automatically started by the drive when host writing behaviors are detected that get better performance when in NVC writing mode. Similarly, NVC writing is discontinued when host commands are received that do not benefit from NVC writing, or when commands, such as rewind, are received. When NVC writing is exited, the drive writes any packed data sets that are accumulated in its buffer before running the command that caused NVC mode to be stopped. Because it is automatically started and stopped, NVC writing is not apparent to host applications. The only indication that NVC writing occurs is the improved capacity and performance that can result from this mode of writing.

The two components of nonvolatile caching, backhitch reduction and data set packing, provide major performance and capacity improvements over standard tape drives, such as the 3590, or Linear Tape-Open (LTO) writing of synchronized data. Data set packing improves overall tape capacity. Backhitch reduction decreases the frequency of mechanical repositions. NVC provides an innovative approach to increasing capacity and write performance in a way that is not apparent to host applications.

3.2.5 Performance or capacity scaling

The 3592 drives support scaling and segmentation modes on the read/write (JA, JB, JC, or JD) cartridges (3592-J1A supports JA only) so that clients can trade off capacity for improved access times.

Important: Capacity scaling is not supported for economy (JJ, JK, and JL) or write-once, read-many (WORM) tapes (JW, JX, JY, JR, and JZ).

While 256 settings of capacity are supported on the 3592 drive, the following settings are often used:

- Full capacity default mode
- A 20% scaled fast access mode (capacity scaled, front of tape through an x'35' setting)
- Performance scaling for 87% capacity (segmented format, capacity scaling setting x'E0')

Performance scaling, also known as *capacity scaling*, is a function through which data can be contained in a specified fraction of the tape, which yields faster locate and read times. This function is made possible through the action of modifying internal formatting indicators in the medium and in the cartridge memory chip.

The normal serpentine track format is altered in such a way as to limit the recorded portion of the tape to a specified fraction of the length of the tape (as shown for 3592-J1A in Figure 3-2 on page 114). In the 3592, an application can issue a **`Mode Select`** command to scale an individual cartridge. It pertains only to the cartridge that is loaded and is not persistent.

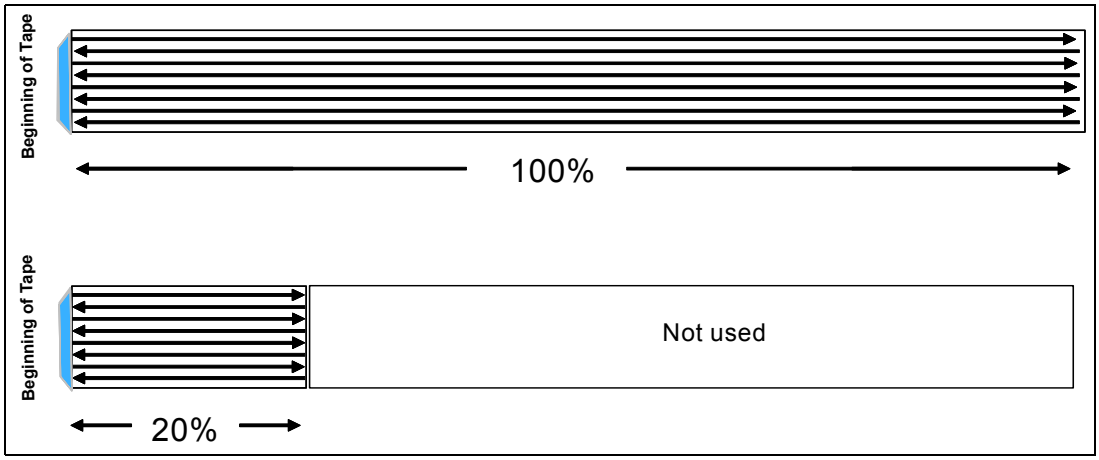


Figure 3-2 Examples for a 100% tape and scaled tape by 20%

The result of performance scaling a tape to a percentage value (for example, 20%) is that the maximum number of recordable gigabytes is reduced to 20% of the normal value. Also, the average time to locate a random record on a full tape starting from load point is (roughly) 20% of the time to locate a random record from load point for a full, unscaled tape.

The cartridge can be rescaled from any current value to any supported new value. Tape is logically erased by this rescaling (the end of data mark is written at the beginning of the tape), but not physically erased as with the long erase command. Scaling or rescaling one cartridge does not cause rescaling of the next cartridge. An explicit command must be issued for each cartridge to be scaled or rescaled.

Performance segmentation

Performance segmentation provides fast access and capacity by allowing the tape to be divided into two segments. One segment is a fast access segment to be filled first, and the other segment is more capacity to be filled after the first segment. Therefore, it is high performance in two ways. It has segmentation and, therefore, has high performance random access in the first segment, as though it was a scaled cartridge, while providing other larger capacity, as shown in Figure 3-3.

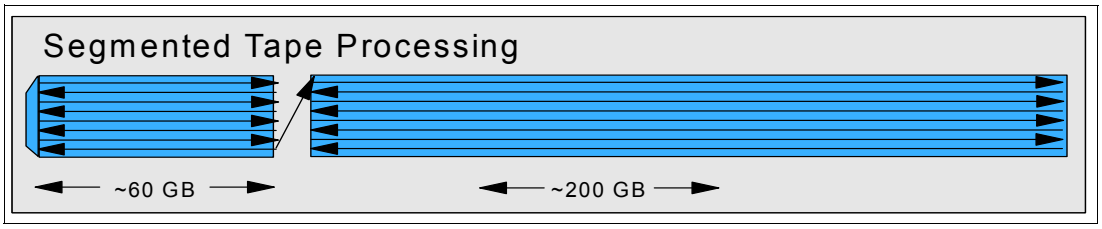


Figure 3-3 Segmented tape on 3592-J1A

Performance capacity scaling and segmentation have the following implications:

- If host systems provide a means to limit the amount of data that a client places on the media, for example, with a percent utilization construct, the user achieves a much faster average access time to the first data. Also, more locates on the same volume improve significantly.
- With segmentation, there is a less than 1% degradation in the data rate because of the increased number of wrap changes. Segmentation also reduces the nominal cartridge capacity by approximately 10%.

3.3 Physical attachment

The 3592 tape drives are supported in various environments, including selected IBM mainframes (zSeries and zEnterprise® systems), IBM System i®, IBM iSeries®, AS/400®, IBM Power Systems (p6 and newer), IBM System p® (p5 and older), RS/6000®, IBM pSeries, IBM System x, IBM xSeries, Oracle, and Hewlett-Packard servers. They also are supported on Intel technology-compatible servers that are running Microsoft Windows and Linux. The 3592 tape drives also can attach to IBM System z® and zSeries servers with the IBM Fibre Connection (FICON) channels by using the IBM 3592 Model C06 and C07 FICON Tape Controllers.

The 3592 tape drives come with dual ported, switched Fibre Channel attachments, 2 Gbps (Model J1A), 4 Gbps (TS1120 and TS1130), and 8 Gbps (TS1140 and TS1150), for attachment to multiple servers or a single server with redundancy. This feature offers attachment flexibility in an open systems environment. The drive can be directly attached to open systems servers with Fibre Channel host bus adapters (HBAs).

The TS1140 and TS1150 tape drives attempt to connect at 8 Gbps, and the TS1120 and TS1130 connect at 4 Gbps and 3592-J1A at 2 Gbps. However, they autonegotiate down to 4, 2, or 1 Gbps if the system or switch to which they are connected cannot support higher bandwidth.

The 3592 tape drives can operate as an NL port (Fibre Channel Arbitrated Loop [FC-AL] support) or as an N port (supporting direct connection to a SAN switch, also known as *point-to-point* or fabric mode). The 3592 tape drives autonegotiate to the N or NL port depending on whether a loop or a point-to-point connection is detected when the drive boots.

The drives do not autonegotiate if the drive was set to force an explicit setting of these configurations. Regardless of whether the 3592 tape drives connect as an NL port or an N port, they autonegotiate to be a public device (attached to a switch) or a private device (attached to another N port, that is, directly to a host).

If a library drive is replaced, an IBM SSR might select the replacement unit to automatically inherit the configuration attributes of the failed unit. This way, a user can avoid reconfiguring the zoning in the switches. Alternatively, the panels can be used to change these fields directly at any time.

For more information about FC attachment planning, see *IBM TotalStorage Enterprise Tape System 3592 Introduction and Planning Guide,* GA32-0555.

For the latest information about applications and their levels that support 3592 tape drives, see the independent software vendor (ISV) matrixes in the document at this website:

`http://www.ibm.com/systems/resources/lto_isv_matrix.pdf`

3.3.1 Multiple Fibre Channel ports

All 3592 models have two independent FC interfaces or ports. Both ports run the SCSI protocol with FC tape support. Through two ports, concurrent attachment of two independent FC configurations can be made to each drive. One or both ports can be attached to various open systems servers, SAN switches, and directors.

The 3592 tape drives support industry-standard shortwave LC-Duplex fibre optic cables, with cable lengths of up to 500 m (1640 ft.) and 50 microns of core fibre, depending on the attachment speed required.

The following maximum distances are supported by the shortwave adapters with the LC-Duplex fibre optic cables:

- 1 Gbps shortwave adapters have a maximum distance of 500 meters (1640 ft.)
- 2 Gbps shortwave adapters have a maximum distance of 300 meters (984 ft.)
- 4 Gbps shortwave adapters have a maximum distance of 150 meters (492 ft.)
- 8 Gbps shortwave adapters have a maximum distance of 50 meters (164 ft.)

3.3.2 Supported topologies

The 3592 tape drives support switched fabric and point-to-point loop topologies.

Switched fabric

Two or more FC endpoints interconnect through a switch. The FC architecture supports up to 256 ports through each switch. Switches include a function called *zoning*. By using this function, the user can partition the switch ports into port groups and then assign group access to other groups. This function prevents group interference. With switched fabrics, all of their ports have simultaneous use of the full FC architecture bandwidth.

Point-to-point loop

A point-to-point loop is similar to a point-to-point topology. Both have two connected FC endpoints. The difference is in the protocol. Therefore, when only two FC endpoints are connected, either protocol is usable. However, both endpoints must use the same protocol. The 3592 model supports a point-to-point loop. Most FC adapters default to the loop protocol when not directly connected to a fabric.

Important: SAN switches normally default the switch port to loop mode. If port is set to automatic mode, loop mode is the first mode that is attempted during the port login process. The 3592 accepts loop mode and logs in to the port. To get the 3592 to log in to the SAN switch port in fabric mode, the port on the switch should be set to fixed fabric mode by the switch administrator or at the drive by using the management interface.

Address assignments

The 3592 tape drives must have an FC address to communicate over the FC interface. The tape drives support hard and soft addressing. Most FC hosts (initiators) support hard addressing and do not support soft addressing. For more information, see the device driver documentation.

Fibre Channel worldwide name ID

Each Fibre Channel card on the 3592 tape drive has four names (Node 0, Node 1, Port 0, and Port 1) that are hardcoded into the electronics of the card by IBM manufacturing. These names are similar to a serial number and are unique throughout the world.

3.4 Media

Users must cost-effectively store more digital information than ever before, often to meet growing regulatory and legal requirements. The 3592 tape drives help to meet these needs with the IBM Tape Cartridge 3592. The 3592-J1A, TS1120, TS1130, TS1140, and TS1150 all use the 3592 tape cartridge. This tape cartridge offers various capacity options, depending on the drive and recording format that are used or the cartridge model that was ordered (Data, Write Once Read Many (WORM), or Economy).

These capabilities expand the range of client data workloads that can be addressed with the 3592 tape drives. The economy cartridge can help lower the cartridge cost for users with smaller capacity needs and provide faster access to data. The WORM cartridges provide nonerasable, nonrewritable storage media. Users with regulatory or legal requirements to store electronic records for long periods might be able to use the 3592 tape drives to provide cost-effective storage.

The 3592 cartridges have a form factor similar to the 3590 tape cartridge. They are supported in the following IBM cartridge library environments:

- IBM 3494 tape library
- IBM TS3500 tape library
- IBM TS4500 tape library

The IBM 3592 ½-inch tape cartridge contains an advanced fourth-generation metal particle formulation in a dual-layer coating on a half-inch-wide tape. The IBM tape uses an advanced magnetic coating and process that provides a high output and signal quality to support the current 3592 tape drives.

The tape features an ultra-smooth and uniform magnetic layer less than 0.2 microns thick and a specially refined coating formulation that is designed to help improve media reliability and performance and minimize wear of the tape heads and components. A precision timing-based servo with enhanced features helps enable high track densities, high data rates, data access performance and high reliability and stop-start performance.

Media type used for the different media types are:

- Dual coat, MP nanocubic particle, PEN substrate 8.9 um nominal thickness, (JA types)
- Dual coat, MP nanocubic particle, PEN substrate 6.6 um nominal thickness, (JB types)
- Dual coat, BaFe particle, Aramid substrate, 5.0 um nominal thickness (JD types)
- Dual coat, Barium Ferrite (BaFe) particle, PEN substrate, 6.1um nominal thickness (JC types)

Modifications to the cartridge design and construction help improve pin retention, hub and clutch engagement, spool alignment and tape stacking within the cartridge. These enhancements help improve reliability and durability of the media and the tape drive. Enhanced assembly strengthens the cartridge at critical locations and helps make the 3592 cartridge less susceptible to damage, such as from being dropped.

The tape is pulled from the cartridge with a leader pin rather than a leader block as in the 3590 cartridge. A sliding door covers the area that was formerly occupied by the leader block in a 3590 cartridge. A locking mechanism prevents the media from unwinding when the cartridge is not in a drive. A special mechanical design provision prevents the 3592 cartridge types from being loaded into 3590 or 3490 drives. If a 3592 cartridge is inadvertently loaded into a 3590, the cartridge present sensor does not change state and the drive does not attempt to load.

3.4.1 3592 media cartridge

This section provides more detail about the 3592 cartridge media.

Media types and compatibility

There are multiple different media types in the 3592 range. The capacity of the 3592 tape cartridge depends on the format used when writing from the beginning-of-tape (BOT). There are two basic formats that are used, Enterprise Format (EFMT) and Enterprise Encrypted Format (EEFMT). Each tape drive model has different formatting capabilities shown in Table 3-1 on page 118

Table 3-1 Read and Write densities supported

Drive type	EFMT1	EFMT2 EEFMT2	EFMT3 EEFMT3	EFMT4 EEFMT4	EFMT5 EEFMT5
3592 J1A	Read/Write	No	No	No	No
TS1120	Read/Write	Read/Write	No	No	No
TS1130	Read only	Read/Write	Read/Write	No	No
TS1140	Read only	Read only	Read/Write	Read/Write	No
TS1150	No	No	No	Read/Write	Read/Write

All 3592 tape drives support cartridge reuse. The 3592 tape cartridges can be reformatted to any tape format that is supported by the tape drive when writing from BOT. When reformatting, all existing data on the cartridge is erased.

Note: Cartridge reuse is dependent on compatibility of the media on the drive being used.

Using the supported densities on the different 3592 drives, they can use different media. Table 3-2 shows the capability of each drive to use different media,

Table 3-2 Drive and cartridge compatibility

Tape Unit	JD, JL, JZ Cartridges	JC, JK, JY Cartridges	JB, JX Cartridges	JA, JJ, JW, JR Cartridges
3592 J1A	No	No	No	Read/Write
TS1120	No	No	Read/Write	Read/Write
TS1130	No	No	Read/Write	Read/Write
TS1140	No	Read/Write	Read/Write	Read only
TS1150	Read/Write	Read/Write	No	No

Table 3-3 shows the media types, native capacity options, and compatibility options that are available with 3592 tape drives.

Table 3-3 IBM TotalStorage Enterprise 3592 media type capability

Media description	Media type	3592 E08, EH8	3592 E07, EH7	3592 E06	3592 E05	3592 J1A	Case color	Label, door, write-protect switch color
Data	JA	Not supported	640 GB [a]	640 GB	500 GB	300 GB	Black	Dark blue
			500 GB[a] E05 format	500 GB E05 format				
			300 GB[a] J1A format	300 GB[a] J1A format	300 GB J1A format			

Media description	Media type	3592 E08, EH8	3592 E07, EH7	3592 E06	3592 E05	3592 J1A	Case color	Label, door, write-protect switch color
Extended Data	JB	Not supported	1600 GB	1 000 GB	700 GB	Not supported	Black	Dark green
			1000 GB E06 format					
Advanced Data	JC	7000 GB (7TB)	4000 GB (4TB)	Not supported	Not supported	Not supported	Black	Dark purple
Advanced Data	JD	10000 GB (10TB)	Not supported	Not supported	Not supported	Not supported	Black	Burnt orange
Economy	JJ	Not supported	128 GB[a]	128 GB	100 GB	60 GB	Black	Light blue
			100 GB[a] E05 format	100 GB E05 format	60 GB J1A format			
			60 GB[a] J1A format	60 GB[a] J1A format				
Advanced Economy	JK	900 GB	500 GB	Not supported	Not supported	Not supported	Black	Light purple
Advanced Economy	JL	2000 GB (2TB)	Not supported	Not supported	Not supported	Not supported	Black	Apricot
Economy WORM	JR	Not supported	128 GB[a]	128 GB	100 GB	60 GB	Silver	Light blue
			100 GB[a] E05 format	100 GB E05 format	60 GB J1A format			
			60 GB[a] J1A format	60 GB[a] J1A format				
WORM	JW	Not supported	640 GB[a]	640 GB	500 GB E05 format	300 GB J1A format	Silver	Dark blue
			500 GB[a] E05 format	500 GB E05 format	300 GB J1A format			
			300 GB[a] J1A format	300 GB[a] J1A format				
Extended WORM	JX	Not supported	1600 GB	1000 GB	700 GB	Not supported	Silver	Dark green
			1000 GB E06 format					
Advanced WORM	JY	7000 GB (7TB)	4000 GB (4TB)	Not supported	Not supported	Not supported	Silver	Dark purple

Media description	Media type	3592 E08, EH8	3592 E07, EH7	3592 E06	3592 E05	3592 J1A	Case color	Label, door, write-protect switch color
Advanced WORM	JZ	10000 GB (10B)	Not supported	Not supported	Not supported	Not supported	Silver	Burnt orange

a. Read Only (RO)

Important:

- The TS1140 can read but not write to a JA, JJ, JW, or JR media.
- The TS1150 cannot read or write to a JA, JW, JJ, JR, JB, or JX media.

Figure 3-4 shows an example of the media types: a full length read/write tape on the left, WORM cartridges in the middle, and economy read/write cartridges on the right. The WORM cartridges have a platinum-colored shell, and the read/write cartridges have a black shell.



Figure 3-4 IBM TotalStorage Enterprise 3592 WORM and read/write cartridges

Labels

The 3592 cartridges use a media label to describe the cartridge type. Figure 3-5 shows a 3592 JD cartridge label. In tape libraries, the library vision system identifies the types of cartridges during an inventory operation. The vision system reads a volume serial number (VOLSER), which is on the label on the edge of the cartridge. The VOLSER contains from one to six characters, which are left-aligned on the label. If fewer than six characters are used, spaces are added. The media type is indicated by the seventh and eighth characters.



Figure 3-5 View of the 3592 cartridge label

Cleaning cartridges

One cleaning cartridge is designed specifically for the 3592 drives. As with the data cartridges, the 3592 cleaning cartridges are not interchangeable with any other model cleaning cartridges (for example, LTO cleaning cartridges). Therefore, both types of cleaning cartridges must be inserted into the library if there are both types of drives in the environment.

The cleaning cartridge also contains a cartridge memory device, which automatically tracks the number of times that it was used. Cleaning cartridges must be replaced after 50 cleaning cycles.

The physical characteristics of the 3592 cleaning cartridge can be used to distinguish it from the 3592 data cartridges. The product label on the top of the cartridge is white with the word “cleaning” printed on it. Instead of the write-protect switch, there is a non-moveable light gray block, shown as 1 in Figure 3-6. The cartridge door is also light gray. If cleaning cartridges with pre-attached labels are ordered, the first three characters of the VOLSER are CLN, as identified by the number 2 label in Figure 3-6.

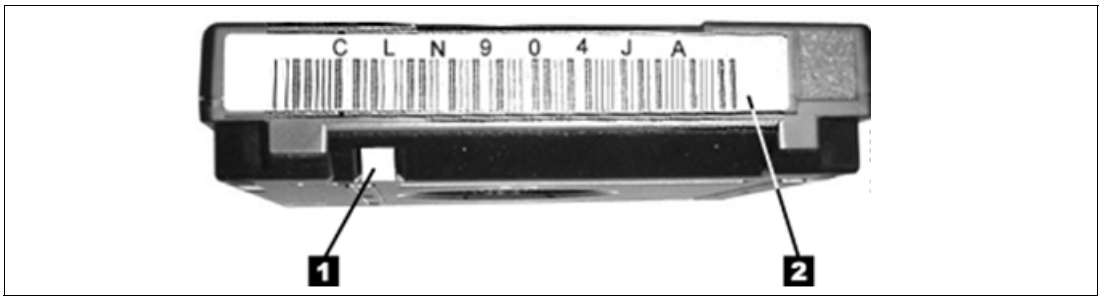


Figure 3-6 Cleaning cartridge

3.4.2 WORM functionality

All 3592 tape drives with the appropriate microcode version installed can read and write WORM cartridges. The WORM data cartridges for the IBM 3592 tape drive provide nonalterable, nonrewritable tape media for long-term records retention. WORM includes the following characteristics:

- WORM cartridges are available in the following formats:
  - JW (full length), which is supported by 3592 J1A, E05, E06, and E07 (read only) tape drives, 640 GB in E06 format, 500 GB in E05 format, and 300 GB in J1A format.
  - JR (short length), which is supported by 3592 J1A, E05, E06, and E07 (read only) tape drives, 128 GB E06 format, 100 GB E05 format, and 60 GB J1A format.
  - JX (extended), which is supported by 3592 E05, E06, and E07, with 1600 GB in E07 format, 1 000 GB in E06 format, and 700 GB in E05 format.
  - JY (advanced), which is supported by the 3592 E07 and E08 tape drives only, 4000 GB (4TB) in E07 format, and 7000 GB (7TB) in E08 format.
  - JZ (advanced), which is supported by the 3592 E08 tape drive only, and 10000 GB (10TB) in E08 format.
  - 300 GB or 60 GB native capacity for the Enterprise 1 (E1) format (3592 J1A), which is available as 700 GB, 500 GB, or 100 GB native capacity for the Enterprise 2 (E2) format (3592 E05). They are also available as 1000 GB, 640 GB, or 128 GB native capacity for the Enterprise 3 (E3) format (3592-E06).
- Nonreversible screws are used to secure the media housing.

- WORM and read/write cartridges can be intermixed within the same IBM TotalStorage Enterprise Automated tape library 3494 or IBM TS3500 tape library.
- When the drive senses that a cartridge is a WORM cartridge, the microcode prohibits changing or altering user data that is already written on the tape. The microcode tracks the last appendable point on the tape with an overwrite-protection pointer that is stored in the cartridge memory.
- Each WORM cartridge is identified by using a World-Wide Cartridge Identifier (WWCID), which is permanent and locked and provides another level of security for data that must be maintained.
- A WORM cartridge never can be made non-WORM and a non-WORM cartridge cannot be made WORM.
- Written user data never can be modified or erased.

WORM basics

The 3592 tape drives support 3592 read/write cartridges and 3592 WORM cartridges. The WORM cartridge is geometrically identical to a read/write cartridge and uses the same rewritable media formulation. However, the servo format, which is mastered onto the tape at manufacturing, is different for WORM cartridge types.

The WORM function does not come from any inherent non-reversible media characteristic (such as permanent WORM on optical CD-R media or optical WORM). Instead, the WORM function is enabled by the method the microcode of the 3592 drive handles a WORM cartridge.

The microcode of the drive does not support overwrite or erasure of previously written user data, such as records or file marks. However, the microcode of the drive supports appending new data following existing data.

Unique cartridge identifier

Each IBM 3592 Tape WORM cartridge is identifiable through a unique cartridge identifier (UCID). The intent of the UCID is that it is constructed to ensure that it is unique worldwide. This identifier is derived from the 4-byte unique cartridge memory serial number of the cartridge memory chip in the 3592 WORM cartridge.

This serial number is concatenated with the 8-byte unique tape serial number that was created from information mastered into the timing-based servo at the time that the cartridge is manufactured.

The parts of UCID that come from this combined serial number are written to a locked part of the cartridge memory. This other level of security supports legal audit requirements. Furthermore, the UCID supports unique cartridge tracking and can be the differentiator to using other WORM tape providers.

Drive operation to prevent overwriting

A WORM drive handles a WORM cartridge differently than a read/write cartridge. In general, a WORM drive responds to a subset of the SCSI commands that work on a read/write cartridge. For example, an **Erase** command is rejected with the appropriate error posted.

Additionally, a WORM drive rejects certain command sequences of otherwise valid commands. For example, if a cartridge is not empty, a **Rewind** command followed by a **Write** command is rejected with the appropriate error posted.

The microcode tracks the last appendable point on the tape by means of an overwrite-protection pointer that is stored in the cartridge memory (CM). Statistical Analysis and Reporting System (SARS) data can be written and updated on WORM tapes because the SARS data is not in the user area of the tape

The 3592 tape drives allow append operations to data already on WORM cartridges, and allow overwrite of file marks and other non-data attributes to provide application transparency. However, they do not allow data overwrite under any circumstances. Once full of data, WORM cartridges cannot be reused or erased by the drive and must be physically destroyed or bulk degaussed to delete data. For full tape application use, certain trailer and label record overwrites are allowed.

Important: WORM cartridges cannot be re-used after they are written to. Therefore, WORM cartridges must be physically destroyed when they are no longer of use. Before it is discarded, if the WORM cartridge has sensitive data, it must be bulk-erased, which erases everything on the tape including the mastered servo pattern and renders it useless.

3.4.3 Tape encryption for TS1120, TS1130, TS1140, and TS1150

The TS1120, TS1130, TS1140, and TS1150 tape drives use an AES encryption key, which is a random string of bits that are generated specifically to scramble and unscramble data. Encryption keys are created by using algorithms that ensure that each key is unique and unpredictable. The longer the key string is, the harder it is to break the encryption code. These drives use 256-bit AES algorithm keys to encrypt data.

The following types of encryption algorithms are used by for encryption:

- Symmetric algorithms

  Symmetric (or secret key) encryption uses a single key for encryption and decryption. Symmetric key encryption generally is used for encrypting large amounts of data efficiently.

- Asymmetric algorithms

  Asymmetric encryption uses a pair of keys. Data that is encrypted by using one key can be decrypted only by using the other key in the asymmetric key pair.

When an asymmetric or public/private key pair is generated, the public key is used for encryption, and the private key is used for decryption.

TS1120, TS1130, TS1140, and TS1150 tape drives use both types of encryption algorithms. Symmetric encryption is used for high-speed encryption of user or host data. Asymmetric encryption (which is slower) is used for protecting the symmetric key that is used to encrypt the data (key wrapping).

The TS1120, TS1130, TS1140, and TS1150 tape drives support three encryption management techniques: System, Application, and Library Managed. For more information about encryption, see 2.2.2, “Encryption methods” on page 69.

IBM Security Key Lifecycle Manager

IBM Security Key Lifecycle Manager (SKLM) is the IBM strategic platform for storage and delivery of encryption keys to encrypting storage end-point devices. The SKLM can be used with the TS1150, TS1140, TS1130, and TS1120 encrypting tape drives.

Like the legacy product, Encryption Key Manager (EKM), IBM SKLM serves data keys to the tape drive. It focuses on ease of use and provides a graphical interface (GUI) to help with the installation and configuration of the key manager. It also allows for the creation and management of the key encrypting keys (certificates).

Important: EKM should no longer be downloaded for new tape encryption installations. EKM still can be downloaded by existing EKM customers that previously implemented EKM, or by IBM i5/OS clients who want to run their key manager on i5/OS. Users that are using the existing EKM can migrate to the new IBM SKLM.

For more information about IBM Security Key Lifecycle Manager, formerly Security Key Lifecycle Manager, see the IBM Security Key Lifecycle Manager V2.5 documentation at this website:

http://ibm.co/1rpMTJk

3.5 IBM TS1150 tape drive

The IBM TS1150 tape drive (which is also referred to as the *3592 Model E08 or EH8)* is the fifth tape drive generation of the IBM 3592 tape family. The TS1150 tape drive is designed to provide higher levels of performance, reliability, and cartridge capacity than the TS1140 Model E07 or EH7 tape drive.

Note: The TS1150 model EH8 is functionally the same as the TS1150 model E07, but packaged for integration into a TS4500. These are discussed in detail in *IBM TS4500 Tape Library Guide*, SG24-8235*5.* We discuss only models 3592 E08 in this section.

The TS1150 has a high-technology, three-module, 32-channel head technology for higher native data rate performance, using Giant Magneto Resistive (GMR) head design,

This provides a native data rate performance of up to 360 MBps versus the 250 MBps data rate of the TS1140 tape drive Model E08.

The TS1150 E08 tape drive has a dual-port 8-Gbps Fibre Channel interface for Fibre Channel attachment to host systems, or a switched fabric environment.

The TS1150 records in two new recording formats, supporting encryption and non-encryption. Enterprise Format 5 (EFMT5) is used to represent the non-encrypted recording format, and Enterprise Encrypted Format 5 (EEFMT5) is used to denote the encrypted recording format.

With these recording formats, the non-compressed capacity of the extended length MEDIA14 and MEDIA15 cartridges is increased from 4 TB to 10 TB.

The TS1150 is downward read/write compatible to the TS1140 formats (EFMT4 or EEFMT4).

Note: TS1150 cannot read or write any format EFMT3 or EEFMT3 and earlier.

Host interfaces to open systems platforms are maintained as with previous 3592 models.

The TS1150 supports integration into the TS3500 tape library, and as stand-alone rack mounted. Figure 3-7 shows the IBM TS1150 tape drive.



Figure 3-7 TS1150 tape drive

The TS1150 tape drive maintains the same features and technology enhancements that were introduced with the TS1120 and extended by the TS1130 and the TS1140. In addition, the TS1150 offers several enhancements over the predecessor models, which are described next.

The TS1150 has the following key features, including those that were introduced with the 3592-J1A, TS1120, TS1130, and TS1140:

- Digital speed matching
- Channel calibration
- High-resolution tape directory
- Recursive accumulating backhitch-less flush or nonvolatile caching (NVC)
- Backhitch-less backspace
- Virtual backhitch
- Read Ahead
- SLDC compression
- Capacity scaling
- Single FRU
- Error detection and reporting
- SARS
- Revised Encryption Support
- Dual-stage 32-head actuator
- Offboard data string searching
- Enhanced logic to report logical end of tape
- Added Partitioning Support.
- Data Safe mode
- Enhanced Ethernet support
- Enhanced Barium Ferrite (BaFe) particle media types
- Dual, 8 Gb FC attachment with failover support
- Partitioning supported by LTFS
- Max Capacity mode LEOT support allowing up to 4% more capacity

3.5.1 Physical attachment

The TS1150 is supported for attachment in the TS3500 tape library or as rack mounted. Table 3-4 shows the attachment configurations that are allowed for TS1150.

Table 3-4 Maximum 3592 tape drive attachments in environments without a tape controller

Environment	Number of TS1140 tape drives
2.0 meter rack (IBM Model 7014-T42)	Up to 16
1.6 meter rack (IBM Model 7014-S00)	Up to 12
1.8 meter rack (IBM Model 7014-T00)	Up to 12
3584 L22 and L23	Up to 12[a]
3584 D22 and D23	Up to 12 per frame[a]

a. There are prerequisites for installing TS1150 into a 3584.
3584 must have enhanced node cards installed,
3584 must have the latest version E Firmware level installed.

3.5.2 Media

The TS1150 introduces the following enhanced Barium Ferrite (BaFe) 2nd generation particle media types that can be used only by the TS1150. The new media can be read/written up to 360 MBps native sustained data rate (up to 700 MBps at 3:1 compression ratio) in the new 32-channel Jag-5 logical format:

- IBM Enterprise Advanced Tape Cartridge (JD) - MEDIA14
- IBM Enterprise Advanced WORM Tape Cartridge (JZ) - MEDIA15
- IBM Enterprise Advanced Economy Tape Cartridge (JL) - MEDIA16

The following TS1150 tape drive capacity and performance improvements are provided on the existing 3592 media:

- The TS1150 tape drive reuses the following TS1140 supported media types:
  - IBM Enterprise Advanced Tape Cartridge (JC) - MEDIA11
  - IBM Enterprise Advanced WORM Tape Cartridge (JY) - MEDIA12
  - IBM Enterprise Advanced Economy Tape Cartridge (JK) - MEDIA13

  Important: The TS1150 is not compatible with some older 3592 cartridge media types, JA, JB, JW, JJ, JR, and JX media types (MEDIA5, MEDIA6, MEDIA7, MEDIA8, MEDIA9, and MEDIA10).

- The TS1150 improves capacity and performance by writing and reading the E08 logical format by using a new 32-channel enhanced ECC recording format with a higher track density and higher linear density on the same media types.
- The appropriate microcode levels that are available for TS1140 must be applied that enable the recognition of the E08 format and allow reuse of the media in the older formats. Thus, a model E08 drive can reformat media that was previously written in the older format and write on it in the appropriate format.

  Important: This design supports a common scratch pool by media type regardless of the last written format or allocation target drive.

3.5.3 Capacity and performance

Capacity and performance were improved from the IBM TS1150 tape drive for all media types and for all formats that the TS1150 reads or writes.

Capacity improvement

The use of the 3592-EH8 logical format offers the following capacity improvements on existing and new cartridges,

- IBM Enterprise Advanced WORM with data media (JZ, JD), a capacity of 10 TB
- IBM Enterprise Advanced WORM with data media, (JC, JY), a capacity of 7 TB
- IBM Enterprise Economy Data media (JZ), a capacity of 2 TB
- IBM Enterprise Economy Data media (JK), a capacity of 900 MB

Using the IBM Enterprise Advanced WORM with data media (JY or JC), a 75% capacity uplift from 4 TB to 7 TB is achieved.

Performance improvement

The overall performance is increased over previous model by various improvements, as shown in the following examples:

- Improved data rate and capacity
- Improved latency by reducing access time to data
- Improved Data Compression
- Beginning of Partition (BOP) Caching
- Humidity Sensor support
- Increased Cartridge Memory size and related functions
- Improved High Resolution Tape Directory (HRTD)
- Larger Main Data Buffer
- Extended Copy support

Higher data rates and capacity

The following format data rates are available:

- The EH8 format data rates go up to 360 MBps maximum native and to 700 MBps maximum compressed.
- The EH7 format data rates go up to 250 MBps maximum native and to 700 MBps maximum compressed.

Table 3-5 summarizes the capacity and performance characteristics for uncompressed data.

Table 3-5 Capacity and performance summary

Media	E08 format capacity data rate (minimum-maximum)	E07 format capacity data rate (minimum-maximum)
JC or JY	7 TB 80 MBps - 300 MBps	4 TB 50 MBps - 250 MBps
JD or JZ	10 TB 90 MBps - 360 MBps	N/A
JK	900 GB 60 MBps - 250 MBps	500GB 50 MBps - 250 MBps
JL	2 TB 60 MBps - 360 MBps	N/A

Improved latency

The TS1150 tape drive adds features to improve latency by reducing access time to data. These features may be summarized as follows:

- Improved locate and rewind speed profile for the new media types using 12.4 m/s end-end versus 12.4 m/s profiled (JD, JZ, and JL media only).
  - JD, JZ, and JL media feature a redesigned brake button for higher reliability, longer life, and higher locate speeds.
  - The improved profile represents a 9% speed improvement for a rewind/locate operation from EOT to BOT versus the previous profile, which partially compensates for the longer tape length of the new media types.
- Load and thread times are reduced by approximately 33% from 15 seconds load/ready to 10 seconds load/ready. This is applicable to both JC and JD media types.

This improvement is possible by operating the motors at higher operating speed for RR, loader, and threader motors.

Improved data compression

The TS1150 features a larger history buffer use in the compression core. This change increases the history buffer from 1K to 16K, which enables more efficient compression by increasing the history over which string matches may be applied. The new method can increase the nominal compression ratio for Calgary Corpus data standard from approximately 2.0 to 2.5.

Note: The improved compression method is available only when processing the EH8 logical formats on the new JD, JZ, and JL media or on unformatted JC, JY, or JK media. When processing the EH7 format, legacy compression method is used for compatibility.

As in previous models, the 3592 tape drive uses the data compression known as Streaming Lossless Data Compression Algorithm (SLDC). This compression method is identical to the method used in previous models with the exception of the larger history buffer. SLDC is an implementation of a Lempel-Ziv class 1 (LZ-1) data compression algorithms. SLDC is an extension to the Adaptive Lossless Data Compression (ALDC) algorithm, which is used in leading industry tape products. Users of SLDC can expect to achieve the same, or better, data compression as users of ALDC.

A key difference between SLDC and previous lossless compression algorithms is that record boundaries and file marks are encoded as control symbols. The encoding of record boundaries and file marks as control symbols allows the compressed data stream to be separated into a serial stream of records and file marks by the decompression logic without requiring additional information such as from an attached header.

Beginning of Partition (BOP) Caching

The TS1150 drive implements Beginning of Partition (BOP) Caching. In this implementation, after the initial set of tape blocks in a partition are read, either by read-ahead function or explicit command, they remain in a special place in the cache data buffer (until unmount or partition change). Subsequent locate operations to BOP or read operations of these blocks complete quickly, without requiring completion of physical motion. BOP Caching is supported in all partition modes.

This feature is automatic, cannot be disabled, and uses approximately 6 MB space (one data set) in the main data buffer.

Humidity sensor

The TS1150 contains a humidity sensor as well as a temperature sensor. The humidity sensor provides the following functions:

- Humidity tracing in drive logs

  The drive logs humidity data in the tape map during read and write.

- Max humidity logging in cartridge memory

  The max humidity sensed during a cartridge mount is loaded in cartridge memory.

- Humidity data externalized in log pages

  Like temperature data, humidity data can now be read through SCSI log pages by an initiator. For more information, see *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference (LTO-5 through LTO-6)*, GA32-0928:

  http://www.ibm.com/support/docview.wss?uid=ssg1S7003556

Increased cartridge memory size and related functions

The new JD, JZ, and JL media types contain 16 KB cartridge memory (CM), increased from the 8KB contained in JC and JB media types. The CM contains a larger MAM area, which is available to the application.

Improved high-resolution tape directory

The TS1150 tape drive provides a higher-granularity directory to improve the accuracy of tape locate operations for the new JD, JZ, and JL media types. The granularity of wrap entries is increased from 64/wrap to 128/wrap for the new media types. High-resolution tape directory (HRTD) resolution for JC media types is unchanged. HRTD directories are maintained separately for partitions

The TS1150 maintains a tape directory structure with a high granularity of information about the physical position of data blocks and file marks on the media. The LPOS longitudinal location information contained in the servo pattern is associated and recorded with the host block information in the HRTD. This feature allows the 3592 to have fast and consistent nominal and average access times for locate operations. Therefore, locate times are uniform and based on the position of the block or file mark on the tape, independent of the uniformity of the block size or file mark distribution along the length of the tape.

The HRTD feature maintains an overall granularity of 64 directory entries per logical wrap. For a JA media 570 m logical wrap, this results in a granularity of 8.9 meters. For a JB media 775m logical wrap, this results in a granularity of 12.1 meters. For a JC media 842 m logical wrap, this results in a granularity of 13.2 meters. For JD media, the nominal granularity with 128 entries is 8.06 meters. For the segmented or scaled formats where there are shorter logical wraps, granularity is improved.

The 3592 drive has many redundancy and recovery features which prevent the possibility of data loss in the event of directory loss and allow rebuild of the directory under all circumstances:

- The HRTD table consists of information for each logical wrap with each wrap area containing up to 64 entries. Each entry contains LPOS, logical block, and file mark count information along with access point and other internal information of interest
- The entire HRTD table is stored in the housekeeping data set on tape. The entire HRTD structure is also written in the EOD (end-of-data) data set for the tape if the tape has a valid EOD. The HRTD entries are also distributed in accumulating sequential fashion into the Data Set Information Table of all user data sets as they are written on tape. Control

structures are in the cartridge memory that defines the validity of the HRTD and EOD information on the tape.

- If a valid HRTD cannot be recovered from the housekeeping data set, the HRTD may be rebuilt using the EOD or distributed copies of HRTD information. The HRTD may also be completely rebuilt by reading the tape. Depending on the mechanism that must be used to rebuild the HRTD, this can occur relatively quickly (seconds in the event the EOD copy can be used) or take longer (minutes if a full rebuild is required).
- The drive can read all data from a cartridge without any HRTD information, although locate times may be affected. However, the drive does not allow a write operation without a valid HRTD to guarantee integrity and validity of the information on tape.

Larger main data buffer

The TS1150 drives features a 2 GB main data buffer, twice the size of the 1 GB main buffer in the TS1140 drive. The larger buffer improves overall performance, reduces back hitches, improves speed matching performance, supports BOP caching, and other improvements.

Extended copy support

The TS1150 supports a new function called External Copy, which offers these advantages:

- The capability is similar to serverless copy in that it allows data to be copied from one drive to another drive with no transfer through the host at very high data rates
- Data can be an entire volume or a group of logical blocks
- The hosting drive (TS1150 or any drive supporting the feature) can pull or push data to a second drive of any type (vendor-neutral and does not require feature support)
- It works in a SAN environment, supported on true switches (non-hubs)

SkipSync, the Same Wrap Backhitchless Flush feature

The TS1150, like previous models, implements a feature known as Same Wrap Backhitchless Flush Mode (SWBF mode), also called the *SkipSync* feature. This feature on the TS1150 is similar to previous models plus the following enhancements:

- In default mode, SkipSync is enabled to use up to 1.5% capacity loss and uses spare capacity, so there is no impact to customer capacity in the nominal Constant Capacity LEOT mode.
- SkipSync may be programmed via Mode page 0x30 to allow up to 33% capacity loss, which essentially enables SkipSync for all transactions.
- The performance (throughput) improves for operations or transaction sizes using SkipSync because of the increased nominal data rates of the TS1150.

How SkipSync operates

When a sync command (**`WFM 0`**) or a Write File Mark non-immediate command is received after a block or series of data blocks (called a *transaction*), the TS1150 drive does not perform a backhitch immediately after the synchronization or WFM is completed. Instead, it continues to stream on the same wrap and write DSS pattern until enough data is received to begin recording additional data sets. This results in a significant performance improvement due to backhitch avoidance but a reduction in the overall available capacity on the volume.

In default mode, SWBF mode (SkipSync) is entered after a flush is received under these conditions:

- The received transaction size is greater than 204 MB compressed.
- The drive is not already in Recursive Accumulating Backhitchless Flush (RABF) mode.

- There is enough remaining excess capacity based on the current logical position that the drive predicts that it will still achieve the Minimum Capacity threshold currently selected. This is 1.5% for TS1150 default mode.

Dynamic speed matching support

The TS1150 drive continues to perform dynamic speed matching to minimize backhitches when operating from a host that cannot sustain the maximum data rate. The drive performs dynamic speed matching automatically to adjust the native data rate of the drive as closely as possible to the net host data rate (after data compressibility has been factored out).

The following data rate ranges depend on the logical format and the media type used:

- 12 speeds, from 112 MBps to 365 MBps for 3592 JD, JZ, and JL cartridges initialized in Gen 5 format
- 12 speeds, from 99 MBps to 303 MBps for 3592 JC, JY, or JK cartridges initialized in Gen 5 format
- 12 speeds, from 62 MBps to 252 MBps for 3592 JC or JY cartridges initialized in Gen 4 format

Throughput is increased through speed matching as the drive performs the following functions:

- Adjusts tape speed based on host data rate
- Calculates effective host data rate (EHDR)
- Optimizes data rate by selecting optimal EHDR
- Forces speed changes mid-wrap if advantageous
- Minimizes time to record data

Virtual backhitch

The TS1150 includes the following key feature improvements:

- Virtual backhitch (transaction write with sync)
- Single wrap backhitchless flush (large transaction writes with sync)
- Backhitchless backspacing (ANSI file writes)

The TS1150 has improved functions, such as *recursive accumulating backhitchless flush* (RABF), and the addition of a new *same wrap backhitchless flush* (SWBF) function that extends virtual backhitch effectiveness for large files.

Fast sync and skip performance for the TS1150 tape drive is enhanced because of the better data rate performance over the TS1140.

For more information about these features, see “Virtual backhitch (nonvolatile caching)” on page 112.

Read Ahead feature

On sequential reads, the tape drive automatically runs Read Ahead and fills the buffer with data sequentially beyond the target block.

The TS1150 supports advanced automatic read-ahead and read-space virtualization at improved access performance and 2X data buffer size. When the drive processes a command to locate or read a block, the drive automatically continues to stream down the tape and read ahead until the data buffer is full. This allows subsequent Locate or Read commands to be fulfilled from the data buffer at faster speeds, rather than requiring access to the tape.

With this unique function, the drive outperforms competitive drives, which stop and wait for the next command.

Performance scaling and segmentation

The TS1150 support for capacity scaling is summarized below. The TS1150 drive supports capacity scaling only on the JD and JC full length R/W media type.

Note: When a scaling operation is requested on a JC type cartridge, the media is reformatted to the J5 logical format at the same time that the scaling operation is performed unless the format is controlled through explicit means.

Format support

The TS1150 drive writes the EH7 scaled format (JC media only) and the scaled EH8 format (on JC and JD media). Segmented formats are supported.

EH7 scaled format behavior on JC is unchanged from the TS1140, and full cartridge Accumulating Backhitchless Flush (ABF) capability is supported on any scaled cartridge.

When a scaled cartridge is up-formatted (applicable to JC media only), the scaling value is retained, and the scaled capacity is uplifted to the capacity ratio of the new format.

Partitioning support

- Scaling is supported only on single partition cartridges.
- Issuing a Format Medium command to attempt to partition a scaled cartridge results in the command being rejected.
- Scaling a partitioned cartridge results in the cartridge being reset to a scaled, single partition format.

The effect of capacity scaling is to contain data in a specified fraction of the tape, which yields faster locate and read times. Alternatively, economy tapes (the JK or JL media type) can be purchased.

Performance scaling limits the data that is written to the first 20% of the cartridge. When the performance segmentation option is used, the overall capacity of the cartridge is limited to 86.6% of the total capacity.

The fast access segment occupies the first 20% of the cartridge, followed by the slower access segment. Medium Capacity is calculated as a fraction of nominal maximum capacity. Scaled medium capacity is approximately equal to the nominal unscaled medium capacity multiplied by this value and divided by 256.

Segmentation is available only within a specified range of capacity scaling settings that achieve this faster performance.

Cartridges that are performance-scaled or performance-segmented can be reused (reformatted) to their full capacity, to the performance-scaled capacity, or to the performance segmentation format as indicated through the assigned data class.

Important: Capacity scaling is not supported for economy (JK, JL) or write-once, read-many (WORM) tapes (JY and JZ).

Tip: Check with the device driver user guide for capacity scaling limitations and instructions for setup.

3.5.4 Access performance specifications and drive characteristics

Table 3-6 summarizes the access performance and drive characteristics of the 3592-E08, 3592-E07, and 3592-E06.

Table 3-6 Access performance specifications and drive characteristics

Parameter	3592-E08 EFMT5 or EEFMT5	3592-E07 EFMT4 or EEFMT4	3592-E06 EFMT3 or EEFMT3
Tape speed, locate/rewind	12.4 mps	12.4 mps	12.4 mps
Drive load/ready time	12 s	15 s	13 s
Block locate time from load point average	40 s for JC, JY 45 s for JD, JZ 11 s for JK 13 s for JL 12 sec 20% scaled JC 13 sec 20% scaled JD	37 s for JB, JX 40 s for JC, JY 11 s for JK 15 sec 20% scaled JB 12 sec 20% scaled JC	28 s for JA, JW 11 s for JJ, JR 37 s for JB, JX 11 sec 20% scaled JA 15 s for 20% scaled JB
Time to first data average (load/ready + locate)	50 s for JC, JY 55 s for JD, JZ 22 s for JK 23 s for JL 23 sec 20% scaled JC 23 sec 20% scaled JD	42 s for JB, JX 55 s for JC, JY 26 s for JK 30 s for 20% scaled JB 27 s for 20% scaled JC	41 s for JA, JW 24 s for JJ, JR 50 s for JB, JX 24 s for 20% scaled JA 28 s for 20% scaled JB
Unload time	36 s for JD, JZ, JL, JC, JY, JK	24 s for JB, JX 36 s for JC, JY, JK	21 s for JA, JW, JR, JJ, JB, JX
Maximum rewind time	76 sec 100% scaled JC, JY 26 sec 20% scaled JC 18 sec JK 94 sec 100% scaled JD, JZ 34 sec 20% scaled JD, JZ 34 sec JL	72 sec 100% scaled JB, JX 24 sec 20% scaled JB 76 sec 100% scaled JC, JY 26 sec 20% scaled JC 18 sec JK	55 sec 100% scaled JA, JW 18 sec 20% scaled JA 18 sec JJ, JR 72 sec 100% scaled JB, JX 24 sec 20% scaled JB
Native Data Rate	360 Mbps	250 Mbps	163 Mbps
Device data rate, maximum sustained with maximally compressible data	700 MB/s	650 MB/s	350 MB/s
Interface burst transfer rate, maximum	800 MB/s (FC-8)	800 MB/s (FC-8)	400 MB/sec (FC-4)
Number of tracks	4608 JC, JK, JY 5120 JD, JZ, JL	1792 JB, JX 2560 JC, JK, JY	1152
Number of passes (from BOT to EOT)	144 JC, JK, JY 160 JD, JZ, JL	56 JB, JX 80 JC, JK, JY	72
Linear density	510 kbpi	500 kbpi	321 kbpi
Servo regions	5	5	5

Parameter	3592-E08 EFMT5 or EEFMT5	3592-E07 EFMT4 or EEFMT4	3592-E06 EFMT3 or EEFMT3
Data tracks recorded simultaneously	32	32	16
Buffer size	2 GB	1 GB	1 GB

3.5.5 Emulation

Emulation mode

The TS1150 does not support any emulation modes. Because the drive cannot write the TS1120 or J1A logical format, it cannot fully emulate all format behaviors of a previous model 3592 drive.

Drive emulation

While the TS1150 tape drive does not support emulation, it can read and write in EFMT5 and EFMT4 format with compatible IBM 3592 tape cartridges. The TS1150 tape drive can reformat any compatible EFMT4 tape when it is writing from BOT. Table 3-7 shows the modes that are available for TS1150.

Table 3-7 Drive emulation for TS1150

Drive mode setting	Formats read	Format used when writing cartridge is at BOT	Format used when writing cartridge is not at BOT	Model type reported to host in response to an Inquiry command
E08	EFMT4 EFMT5	EFMT5 EFMT5	EFMT4 EFMT5	E08

3.5.6 Linear Tape File System (LTFS) partitioning support

Tape as a storage medium has many benefits: It is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use, because it has no standard format and data often cannot be used without first copying it to a disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as intuitive as the use of a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping a file. Users can run any application that is designed for disk files against tape data without concern for the fact that the data is physically stored on tape.

LTFS implements a true file system for tape. LTFS also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM LTFS provides support for IBM tape automation and the single drive edition IBM Linear Tape File System. LTFS Library Edition provides the ability to create a single file system mount point for a logical library that is managed by a single instance of LTFS, which is running on a single computer system. In addition, it provides for caching of tape indexes, and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

For more information about LTFS-SDE, see *IBM Linear Tape File System Installation and Configuration*, SG24-8090.

The TS1150 provides LTFS support with the following features:

- Ability to configure up to four partitions
- Wrap-wise and longitudinal-wise partitioning
- Supported on all non-WORM TS1140 formats (JC, JK, and JB formats)
- Format command support
- Each partition can use a separate encryption method, or none

The TS1150 drive supports partitioning in an identical manner to previous E07 model, except the capacity of a given partition scales up with the newly supported J5 format.

- The TS1150 drive will support both the wrap-wise and longitudinal partitioning models and the same number of partitions.
- The TS1150 drive will support the partitioning of WORM media types (JD and JY media types) to enable LTFS support on WORM media.
- As introduced on TS1140, the TS1150 supports a default a wrap-wise partitioning model with minimal capacity loss at the expense of ABF capability within all partitions at all times.

Partitioning allows a volume to be split into multiple logical partitions, each of which may be read, navigated, written, erased, appended, updated, and managed as separate logical entities, with unique logical block sequences.

The primary user of this partitioning capability is the LTFS, which partitions a volume into two logical partitions: an index partition and a data partition. The TS1150 drive supports both TS1140 style partitions.

The TS1150 supports additional partitioning enhancements, Specifically, both wrap-wise partitioning and longitudinal partitioning methods.

The following apply in general to partitioning support on the E08:

- Partitioning is supported on media in the TS1140 and TS1150 logical formats.

  In the case of JC media re-use, issuing of a Format Medium command performs an implicit reformat to the TS1150 format if the media is in the TS1140 format.
- Partitioning is only supported on unscaled, R/W Data and WORM media types which support writing in the TS1140 or TS1150 format

  In the case of scaled media, the Format Medium command is rejected.

  Attempts to scale a partitioned media are accepted. As part of scaling, the volume is set to a single data partition cartridge.

  See *IBM 3592 SCSI Reference*, GA32-0562, for details about partitioning behavior:

  http://ibm.co/1xFWL2o

Wrap-wise Partitioning

Figure 3-8 on page 136 depicts wrap-wise partitioning, the following applies to wrap-wize partitioning in the TS1150:

- A maximum of four partitions are supported; two or three partitions can be assigned if desired.
- A minimum of two wraps are allocated to a partition, regardless of the minimum selected capacity.
- Full length of tape (LP3 to LP5) is always assigned to each partition.
- In general, two physical wraps between partitions are reserved as guard wraps. Therefore, some percent of usable capacity may be lost, up to 3% per partition boundary.

- RABF operations are performed in any partition if spare usable Accumulating Backhitchless Flush (ABF) wraps exist within a partition. In general, the last four wraps of a partition, or any partition smaller than four wraps, does not support RABF operation.

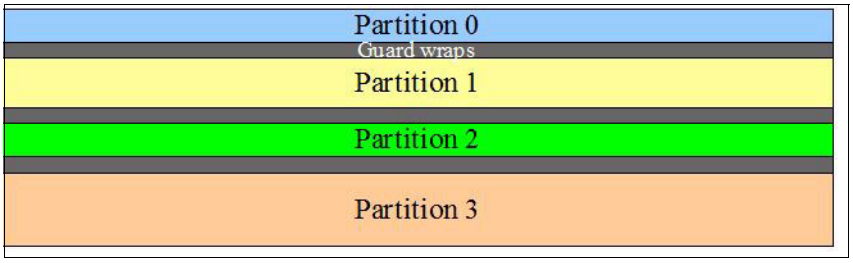


Figure 3-8 Wrap-wise Partitioning

Longitudinal partitioning

Figure 3-9 depicts longitudinal partitioning. The following apply to longitudinal partitioning in the TS1150:

- A maximum of four partitions are supported.
- A minimum of 50 meters is allocated to a longitudinal partition.

  The physical data wraps on the portion of tape that is assigned to the partition belong exclusively to each logical partition that is configured. Each partition starts from wrap 0 and ends on the last wrap.
- A guard gap between partitions is reserved to protect user data against systematic debris accumulation. The guardband is approximately 7 meters and results in a capacity loss of less than 1%.
- RABF is performed within the boundaries of each partition, with the same wrap sequence as base J5 RABF operation.

  Performance is slightly poorer due to less total ABF wrap length.

  Just as in non-partitioned media, the last four wraps' RABF cannot be used.
- Better performance is provided for random access because of shortened tape length for the partition.

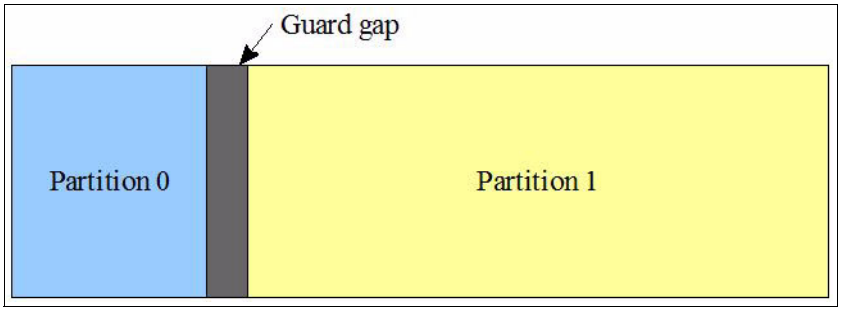


Figure 3-9 Longitudinal partitioning

3.5.7 Data safe mode

TS1150 supports *data safe mode*. This mode is controlled by the application and prevents inadvertent overwrite. Data safe mode treats the tape volume that is mounted as WORM drive and prevents inadvertent overwrite. This mode is set by the application or host system.

3.5.8 Enhanced Ethernet support

The 3592 Model E08 tape drive includes an Ethernet port for use by an IBM Service Support Representative (SSR) for procedures such as updating microcode, uploading a drive memory dump, or viewing drive status. The Ethernet port on the TS1150 also can be used by the user for providing the capability to access a drive's virtual operator panel and advanced status pages remotely by attaching an Ethernet cable from the drive to the users' network.

Important: The Ethernet function is not supported on TS1150 drives in a TS3500 tape library.

Expanded Ethernet port functionality

The Ethernet port is used in the TS1150 Rack mount configuration, when in a TS3500 tape library configuration the TS3500 tape library management interface (MI) can be used to manage the TS1150 instead. Figure 3-12 on page 139 shows the location of the Ethernet port.

3.5.9 TS1150 physical characteristics

The TS1150 tape drive includes an identical form factor and is plug-compatible with existing 3592 models. It maintains low power and improves power management. The maximum continuous operating power decreased by 5 watts from the TS1140. The drive power use is 46 watts maximum operating power, as compared to 51 watts for the TS1140. Standby power is fewer than 23 watts.

The TS1150 has a standby cooling management feature, which reduces the fan speed when idle to further reduce power and reduce airborne debris contaminants. The fan operating mode is controlled by a single input signal called *full-speed mode* or *variable-speed mode*. In full-speed mode, the fan or blower runs at full speed. In variable-speed mode, the blower adjusts its speed based on the ambient temperature down to a minimum of about 50% of its full speed.

The speed of the fan is based on the following conditions:

- 3592-EH8 drive code enables variable-speed mode under the following conditions:
  - The drive is unloaded and idle for five minutes.
  - The internal temperature is at least 3 degrees below the full speed required temperature limit.
- The drive code reverts to full-speed mode as soon as the following conditions are met:
  - A cartridge is placed in the loader or loaded.
  - The internal temperature of the drive rises above the full speed required temperature limit.

The internal temperature sensor is sampled at five-minute intervals.

3592 packaging

As in previous models, the TS1150 tape drive is a canister with a drive that is packaged inside the canister. Unique markings on the front and rear of the canister allow the identification of an E08 from a previous version of the drive. The canister enclosure provides mounting, connections, fiducial labels for calibration, and status LEDs for the use in automation frames. Figure 3-10 on page 138 shows the standard TS1150 drive canister.



Figure 3-10 TS1150 canister

The front panel of the TS1150 is shown in Figure 3-11, contains all operator controls and display.

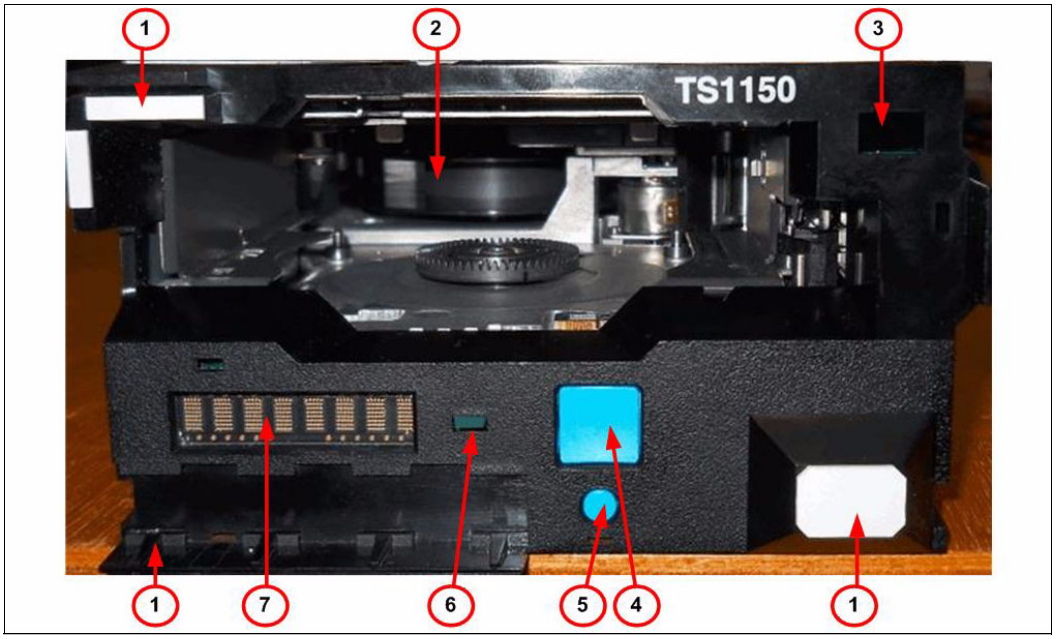


Figure 3-11 TS1150 front panel

Table 3-8 on page 139 describes the front panel of the TS1150.

Table 3-8 TS 1150 front panel

Reference number	Item	Item More information
1	Reflective fiducial	Used by library accessor Upper left, C20 Silo. Lower-left, Quantum Scalar library. Lower right, 3494.
2	Tape cartridge slot	Area where tape cartridge is loaded
3	Non-reflective fiducial	Used by TS3500
4	Unload button	Press to manually unload a tape cartridge
5	Reset button	Press to generate a drive reset
6	LED power indicator	Green LED indicates that power is applied. Yellow during activities like a microcode load and reset
7	Eight-character (message) display	Information area for operator. This display provides FID messages, attention drive messages, clean messages, and drive status.

The canister is mounted in various forms of mounting hardware for use in different automation systems. The drive unit is inside the canister. The TS1150 drive has the same physical form factor as the TS1140, TS1130, TS1120, and 3592-J1A drive. Thus, only the complete canister can be changed or replaced and not the drive alone.

The 3592-E08 canister no longer has an RS-232 serial port. An Ethernet service port was added to the drive, which is for service, and use by the user. It provides the capability for users to access advanced drive status pages and for service personnel to access a drive virtual operator panel and perform firmware uploads and download drive memory dumps. It is a single, standard RJ45 connector at the rear of the canister, as shown in Figure 3-12.

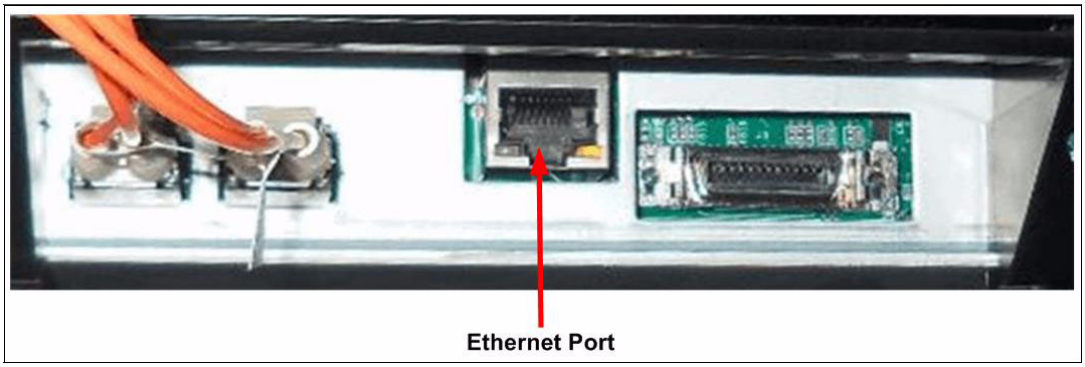


Figure 3-12 TS1150 Ethernet port

Important: This product might not be certified in the country of installation for connection by any means whatsoever to interfaces of public telecommunications networks. Further certification might be required by law before making any such connection. Contact IBM for more information.

Internal hardware enhancements

The TS1150 features the following significant hardware enhancements over the previous models:

- 32-channel enhanced ECC recording format.
- Enhanced JD-type media servo pattern.
- Flangeless rollers, which are designed to minimize tape edge damage and debris buildup by elimination of the roller flanges.
- Giant Magneto Resistive Heads (GMR head). This advanced high gain head is designed to reduce friction. It has advanced head coating to prevent corrosion and to extend head and tape cartridge life.
- Skew Actuator, which allows dynamic skew adjustment of the head to keep head perpendicular to tape.
- Data-dependent, noise-predictive, maximum-likelihood (DD-NPML) detection scheme was developed at IBM Research, Zurich to enable the accurate detection of data errors.

3.5.10 Upgrade considerations

A drive-field Miscellaneous Equipment Specification (MES) conversion feature is available for a 3592-E07 model to 3592-E08 model conversion to a TS1150. If this method is chosen to replace the TS1140 drive, only the drive changes; the canister remains the same.

The serial number of the original drive is written by the library to the vital product data (VPD) of the replacement drive. The MES is valid for both the TS3500 tape library and a rack-mounted drive.

TS1150 Field MES support

The following drive MES conversions are supported:

- 3592 E07 drive > 3592 E08 model upgrade
- 3592 EH7 drive > 3592 EH8 model upgrade
- 3592 E08 drive > 3592 EH8 model conversion

Note: It is important for a TS1140 drive to have iADT-capable microcode loaded before conversion to the EH8 model. Without it, communication to the library is not possible. It can be obtained from IBM Fix Central. Only one MES model upgrade is supported in the life of the drive.

3.5.11 Firmware updates

No changes were made to the firmware update mechanisms for the TS1150 compared to TS1140 tape drives:

- All four mechanisms currently supported for microcode updates on the 3592-E07 also provide support on the E08
- The TS1150 continues to support concurrent Licensed Internal Code load with deferred activation.
- The TS1150 has a single Licensed Internal Code image unique from previous models. A unique LOAD ID and incremented RU name field is assigned for the 3592-E08 drive.

Unique Licensed Internal Code is required for the model E07 drives, because the LOAD ID differs from the LOAD ID that is required for previous versions of 3592. The firmware for the 3592-E08 drive can be updated by using one of the following methods, depending on where the drive is installed:

- Through the host attachment by using the write buffer command
- Through the Ethernet port on the drive
- Through the library RS-422 port to the drive canister (not supported on rack mount)
- Through the use of an FMR cartridge (might not be supported on automation systems)

3.5.12 RAS

The RAS features are improved or maintained relative to the TS1140. Similar to its predecessor models, the TS1150 is a single FRU, which is hot pluggable without a maintenance window and supports nondisruptive code loading. As with TS1140, there is fan speed management and unique device microcode file management through a LOAD ID. Support is available for a larger service display.

The end-of-life use alert for media becomes activated on full file pass use. The Nearing Media Life alert is given at 19,900 mounts or 295 full-file passes. The Media Life alert for JD or JL media use within a TS1150 drive is now rated for 20 M motion meters as opposed to 300 FFP.

3.5.13 Improved media SARS

The TS1150 supports SARS in a similar manner to previous drive models.

The tape drive uses the Statistical Analysis and Reporting System (SARS) to assist in isolating failures between media and hardware. The SARS uses the cartridge performance history saved in the cartridge memory (CM) module and the drive performance history kept in the drive flash EEPROM to determine the more likely cause of failure. SARS can cause the drive to request a cleaner tape through use, to mark the media as degraded, and to indicate that the hardware has degraded.

SARS information is reported through the TapeAlert flags, and through MIM or SIM messages.

The 3592 drive maintains a history of the last 100 mounts for both Volume (VSARS) and Hardware (HSARS).

Note: Media SARS information is preserved when media is re-formatted

The TS1150 implements an enhanced SARS function known as ccSARS or customer-centric SARS. This function improves the overall amount of information maintained and the presentation means to the customer in concert with the automation system.

The media SARS function for the TS1150 includes the following:

- Tape alerts are generated when media passes use life, as determined by full-file passes, meters of tape processed, or write pass count, and the total number of mounts (already supported).
- A media SARS summary is maintained in the cartridge memory in a manner where it can be rebuilt on tape if the SARS records on tape cannot be read and must be reinitialized. This cartridge memory copy also is readable on an earlier level TS1140 drive to preserve SARS information between logical format conversions.

3.5.14 Encryption

The TS1150 tape drive is encryption-capable. Like the TS1140, there is no need to enable the drive explicitly.

Encryption on TS1150 includes the following enhancements:

- LME, SME, AME, T10 default method support
- Continued EEDK wrapped key support in LME, SME
- Enhanced protocol support for IPP and Java 2, Enterprise Edition (J2EE) legacy mode (as used by IBM Tivoli Storage Manager), T10 default method, SPIN and SPOUT.
- Enhanced drive cryptographic upgrades to change the default authentication means from SHA-1 to SHA-2 when using IBM Security Key Lifecycle Manager.
- T10 standards-based encryption control on a logical block basis (not tied to format identifier), and writes encrypted data and clear data to the same tape cartridge.

3.6 IBM TS1140 tape drive

The IBM TS1140 tape drive (which is also referred to as the *3592 Model E07)* is the fourth tape drive generation of the IBM 3592 tape family. The TS1140 tape drive is designed to provide higher levels of performance, reliability, and cartridge capacity than the TS1130 Model E06 tape drive.

The TS1140 has a high-technology 32-channel Giant Magneto Resistive (GMR) head design, and provides a native data rate performance of up to 250 MBps versus the 160 MBps data rate of the TS1130 tape drive Model E06.

The TS1140 E07 tape drive has a dual-port 8-Gbps Fibre Channel interface for Fibre Channel attachment to host systems, or a switched fabric environment.

The TS1140 records in two recording formats, supporting encryption and nonencryption. Enterprise Format 4 (EFMT4) is used to represent the non-encrypted recording format, and Enterprise Encrypted Format 4 (EEFMT4) is used to denote the encrypted recording format. With these recording formats, the non-compressed capacity of the extended length MEDIA11 and MEDIA12 cartridges is increased from 1 TB to 4 TB.

The 3592 Model E07 is downward read compatible to the 3592 Model E05 and J1A format (EFMT1/EFMT2) and is downward read/write compatible to the 3592 Model E06 formats (EFMT3/EEFMT3).

Host interfaces to System z and open systems platforms are maintained. The TS1140 tape drive is supported for System z by the use of IBM 3592 Model C06 and C07 FICON Tape Controllers, and the TS7700 Virtualization Engine that uses 8 Gbps dual port fibre cards.

The TS1140 supports integration into the TS3500 tape library, and as stand-alone rack mounted. Figure 3-13 shows the IBM TS1140 tape drive.



Figure 3-13 TS1140 tape drive

The TS1140 tape drive maintains the same features and technology enhancements that were introduced with the TS1120 and extended by the TS1130. In addition, the TS1140 offers several enhancements over the predecessor models, which are described next.

The TS1140 has the following key features, including those that were introduced with the 3592-J1A, 3592-E05, and 3592-E06:

- Digital speed matching
- Channel calibration
- High-resolution tape directory
- Recursive accumulating backhitch-less flush or NVC
- Backhitch-less backspace
- SLDC compression
- Capacity scaling
- Single FRU
- Error detection and reporting
- SARS
- Revised Encryption Support
- Dual-stage 32-head actuator
- Offboard data string searching
- Enhanced logic to report logical end of tape
- Added Partitioning Support.
- Data Safe mode
- Enhanced Ethernet support
- Enhanced Barium Ferrite (BaFe) particle media types
- 8 Gbps Fibre Channel (FC) dual port interface.

3.6.1 Physical attachment

The TS1140 is supported for attachment in the TS3500 tape library or as rack mounted. Table 3-9 shows the attachment configuration that is allowed for TS1140.

Table 3-9 Maximum 3592 tape drive attachments in environments without a tape controller

Environment	Number of TS1140 3592 drives
2.0 meter rack (IBM Model 7014-T42)	Up to 16
1.6 meter rack (IBM Model 7014-S00)	Up to 12
1.8 meter rack (IBM Model 7014-T00)	Up to 12
3584 L22 and L23	Up to 12[a]
3584 D22 and D23	Up to 12 per frame[a]

a. There are prerequisites for installing TS1140 into a 3584.
3584 must have enhanced node cards installed,
3584 must have the latest version B Firmware installed.

3.6.2 Media

The TS1140 introduces the following enhanced Barium Ferrite (BaFe) particle media types that can be used only by the TS1140. The new media can be read/written up to 250 MBps native sustained data rate (up to 650 MBps at 3:1 compression ratio) in the new 32-channel Jag-4 logical format:

- IBM Enterprise Advanced Tape Cartridge (JC) - MEDIA11
- IBM Enterprise Advanced WORM Tape Cartridge (JY) - MEDIA12
- IBM Enterprise Advanced Economy Tape Cartridge (JK) - MEDIA13

The following TS1140 tape drive capacity and performance improvements are provided on the existing 3592 media:

- The TS1140 tape drive reuses the following TS1130 and TS1120 supported media types:
  - IBM 3592 Extended Tape Cartridge (JB) - MEDIA9
  - IBM 3592 Extended WORM Tape Cartridge (JX) - MEDIA10

  Important: The 3592 Model E07 is read-only compatible with the older 3592 media types (MEDIA5, MEDIA6, MEDIA7, MEDIA8), cartridge types JA, JW, JJ, and JR.

- The TS1140 improves capacity and performance by writing and reading the E07 logical format by using a new 32-channel enhanced ECC recording format with a higher track density and higher linear density on the same media types.
- The TS1140 supports downward reading of 3592 J1A and TS1120 native formats and writing and reading the TS1130 format.
- The appropriate microcode levels that are available for TS1120 and TS1130 must be applied that enable the recognition of the E06 format and allow reuse of the media in the older formats. Thus, a model E05 or E06 drive can reformat media that was previously written in the older format and write on it in the appropriate format.

  Important: This design supports a common scratch pool by media type regardless of the last written format or allocation target drive.

3.6.3 Capacity and performance

Capacity and performance were improved from the IBM TS1130 tape drive for all media types and for all formats that the TS1140 reads or writes.

Capacity improvement

The use of the 3592-E07 logical format offers the following capacity improvements on existing and the cartridges:

- IBM Enterprise Extended WORM with data media (JB or JX) has a 60% capacity uplift from 1 TB to 1.6 TB
- IBM Enterprise Advanced WORM with data media (JC or JY) has a capacity of 4.0 TB
- IBM Enterprise Economy Data media (JK) has a capacity of 500 GB

Performance improvement

The overall performance is increased by various improvements, as shown in the following examples:

- Improved data rate
- Larger 1 GB main data buffer
- Better backhitching
- Improved speed with digital speed matching
- Enhanced read-ahead buffer management
- High access performance for locate/search
- Improved communication links, with dual 8 Gbps fibre ports
- SkipSync and FastSync write performance accelerators
- New 32-channel enhanced ECC recording format

Higher data rates

Performance is improved from the TS1130 up to 64% in TS1140 mode, 50% in TS1130 mode for read and writes, and 50% in TS1120 mode for reads only. The following format data rates are available:

- The E07 format data rates go up to 250 MBps maximum native and to 650 MBps maximum compressed.
- The E06 format data rates go up to 200 MBps maximum native and to 650 MBps maximum compressed.
- The E05 format data rates go up to 104 MBps maximum native and to 650 MBps maximum compressed.

Table 3-10 summarizes the capacity and performance characteristics for uncompressed data.

Table 3-10 Capacity and performance summary

Media	E07 format capacity data rate (minimum–maximum)	E06 format capacity data rate (minimum–maximum)	E05 format capacity data rate (minimum–maximum)
JB/JX	1.6 TB 80 MBps–200 MBps	1 TB 50 MBps–160 MBps	700 GB 40 Mbps - 150 Mbps
JC/JY	4 TB 90 MBps–250 MBps	N/A	N/A
JK	500 GB 60 MBps–250 MBps	N/A	N/A

Buffer

The TS1140 E07 tape drive has a 1 GB internal data buffer. Along with enabling higher performance characteristics, the data buffer uses support read ahead of compressed data from tape and provides high performance random skip forward sequential (short hop) locates that are common in database search and tape software recycle operations.

This improves the drive agility, file access, and small file handling, which might still be a requirement on IBM z/OS® platforms. Furthermore, the buffer reduces backhitches for all workloads and improves overall read/write performance.

Offboard data string searching

The TS1140 E07 tape drive can search the data content of host records for string matches offboard from the host server. The tape drive can perform this search at maximum data rate (250 MBps native). It takes much longer for a host server to read the data, buffer the data to disk, and then parse the actual data stream with host software routines.

Enhanced logic to report logical end of tape

Logical end-of-tape (LEOT) is now reported, based on a combination of capacity-based and position-based LEOT indicators. The TS1140 E07 monitors the total accumulated number of physical tape data sets that are written to the volume and reports LEOT based on this capacity-based LEOT value. This allows tape copies to complete without overflow at a much higher percentage of the time.

High-resolution tape directory

The TS1140 E07 tape drive maintains a tape directory structure with a high granularity of information about the physical position of data blocks on the media. This feature and the increased search speed allow the TS1140 E07 to have improved nominal and average access times for locate operations versus previous IBM tape drives

Speed matching

The speed matching function is improved on the TS1140 drive because the number of speeds and the range of supported data rates is improved. The following data rate ranges depend on the logical format and the media type used:

- 13 speeds, from 76 MBps to 251 MBps for 3592 JC/JK/JY cartridges initialized in Gen 4 format
- 13 speeds, from 74 MBps to 203 MBps for 3592 JB/JX cartridges initialized in Gen 4 format
- 13 speeds, from 41 MBps to 163 MBps for 3592 JB/JX cartridges initialized in Gen 3 format
- 13 speeds, from 39 MBps to 151 MBps for 3592 JB/JX cartridges initialized in Gen 2 format
- 13 speeds, from 18 MBps to 72 MBps for 3592 JA/JJ/JR/JW cartridges initialized in Gen 1 format
- 13 speeds, from 36 MBps to 144 MBps for 3592 JA/JJ/JR/JW cartridges initialized in Gen 2 or Gen 3 format

Throughput is increased through speed matching as the drive performs the following functions:

- Adjusts tape speed based on host data rate
- Calculates effective host data rate (EHDR)
- Optimizes data rate by selecting optimal EHDR
- Forces speed changes mid-wrap if advantageous
- Minimizes time to record data

Virtual backhitch

The TS1140 includes the following key feature improvements:

- Virtual backhitch (transaction write with sync)
- Single wrap backhitchless flush (large transaction writes with sync)
- Backhitchless backspacing (ANSI file writes)

The TS1140 has improved functions, such as recursive accumulating backhitchless flush (RABF), and the addition of a new same wrap backhitchless flush (SWBF) function that extends virtual backhitch effectiveness for large files.

For more information about these features, see “Virtual backhitch (nonvolatile caching)” on page 112.

Read Ahead

On sequential reads, the tape drive automatically runs Read Ahead, and fills the buffer with data sequentially beyond the target block.

The 3592-E07 supports Read Ahead of approximately 1000 MB of compressed data from tape. When the drive processes a command to locate or read a block, the drive automatically continues to stream down the tape and read ahead until the data buffer is full. This allows subsequent Locate or Read commands to be fulfilled from the data buffer at faster speeds, rather than requiring access to the tape.

The drive outperforms competitive drives, which stop and wait for the next command, with this unique functionality.

Performance scaling and segmentation

The TS1140 tape drives support capacity scaling for tape cartridges of media types JB and JC over a broad range of capacities. The effect of capacity scaling is to contain data in a specified fraction of the tape, which yields faster locate and read times. Alternatively, economy tapes (the JJ or JK media type) can be purchased.

Performance scaling limits the data that is written to the first 20% of the cartridge. When the performance segmentation option is used, the overall capacity of the cartridge is limited to 86.6% of the total capacity.

The fast access segment occupies the first 20% of the cartridge, followed by the slower access segment. For example, with the Model E07 tape drive operating in EFMT4 format, the 3592 Advanced Data Tape Cartridge (type JC) can be scaled to 800 GB. By using performance segmentation, the 4000 GB Extended Data cartridge can be segmented into an 800 GB fast access segment and a 3200 GB slower access segment.

Segmentation is available only within a specified range of capacity scaling settings that achieve this faster performance.

Cartridges that are performance-scaled or performance-segmented can be reused (reformatted) to their full capacity, to the performance-scaled capacity, or to the performance segmentation format as indicated through the assigned data class.

Important: Capacity scaling is supported for economy (JJ, JK) or write-once, read-many (WORM) tapes (JW, JX, JY, and JR) in read-only mode.

Tip: Check with the device driver user guide for capacity scaling limitations and instructions for setup.

3.6.4 Access performance specifications and drive characteristics

Table 3-11 summarizes the access performance and drive characteristics of the 3592-E07, 3592-E06, and 3592-E05.

Table 3-11 Access performance specifications and drive characteristics

Parameter	3592-E07 EFMT4 or EEFMT4	3592-E06 EFMT3 or EEFMT3	3592-E05 EFMT2 or EEFMT2
Tape speed, locate/rewind	12.4 mps	12.4 mps	10 mps
Drive load/ready time	15 s	13 s	13 s
Block locate time from load point average	37 s for JB, JX 40 s for JC, JY 11 s for JK 15 sec 20% scaled JB 12 sec 20% scaled JC	28 s for JA, JW 11 s for JJ, JR 37 s for JB, JX 11 sec 20% scaled JA 15 s for 20% scaled JB	33 s for JA, JW 11 s for JJ, JR 45 s for JB, JX 15 s for 20% scaled JB
Time to first data average (load/ready + locate)	42 s for JB, JX 55 s for JC, JY 26 s for JK 30 s for 20% scaled JB 27 s for 20% scaled JC	41 s for JA, JW 24 s for JJ, JR 50 s for JB, JX 24 s for 20% scaled JA 28 s for 20% scaled JB	46 s for JA, JW 24 s for JJ, JR 58 s for JB, JX 28 s for 20% scaled JB
Unload time	24 s for JB, JX 36 s for JC, JY, JK	21 s for JA, JW, JR, JJ, JB, JX	23 s for JA, JW, JR, JJ, JB, JX
Maximum rewind time	72 sec 100% scaled JB, JX 24 sec 20% scaled JB 76 sec 100% scaled JC, JY 26 sec 20% scaled JC 18 sec JK	55 sec 100% scaled JA, JW 18 sec 20% scaled JA 18 sec JJ, JR 72 sec 100% scaled JB, JX 24 sec 20% scaled JB	66 sec 100% scaled JA, JW 18 sec 20% scaled JA 18 sec JJ, JR 90 sec 100% scaled JB, JX 24 sec 20% scaled JB
Native Data Rate	250 Mbps	163 Mbps	104 Mbps
Number of tracks	1792 JB, JX 2560 JC, JK, JY	1152	896
Number of passes (from BOT to EOT)	56 JB, JX 80 JC, JK, JY	72	56
Linear density	500 kbpi	321 kbpi	282 kbpi
Servo regions	5	5	5
Data tracks recorded simultaneously	32	16	16

Parameter	3592-E07 EFMT4 or EEFMT4	3592-E06 EFMT3 or EEFMT3	3592-E05 EFMT2 or EEFMT2
Buffer size	1 GB	1 GB	512 MB

3.6.5 Emulation

Emulation mode

The 3592 model E07 does not support any emulation modes. Because the drive cannot write the TS1120 or J1A logical format, it cannot fully emulate all format behaviors of a previous model 3592 drive.

Drive emulation

While the TS1140 tape drive does not support emulation, it can read in EFMT2, EFMT3, and EFMT4 format. It also can write in EFMT3 and EFMT4 format with compatible IBM 3592 tape cartridges. The TS1140 tape drive can reformat any compatible EFMT2, EFMT3, or EFMT4 tape to EFMT3 or EFMT4 format when it is writing from BOT. Table 3-12 shows the modes available for TS1140.

Table 3-12 Drive emulation for TS1140

Drive Mode Setting	Formats read	Format used when writing cartridge is at BOT	Format used when writing cartridge is not at BOT	Model type reported to host in response to an Inquiry command
E07	EFMT1 EFMT2 EFMT3 EFMT4	EFMT3 EFMT4	EFMT3 EFMT4	E07

3.6.6 LTFS partitioning support

The TS1140 provided for LTFS support with the following features:

- Ability to configure up to four partitions
- Wrap-wise and longitudinal-wise partitioning
- Supported on all non-WORM TS1140 formats (JC, JK, and JB formats)
- Format command support
- Each partition can use a separate encryption method, or none

Tape as a storage medium has many benefits: it is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use; it has no standard format, and data often cannot be used without first copying it to disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as intuitive as the use of a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. Users can run any application that is designed for disk files against tape data without concern for the fact that the data is physically stored on tape.

LTFS, which works on LTO-5 and TS1140, implements a true file system for tape. LTFS also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM LTFS provides support for IBM tape automation and the single drive edition IBM Linear Tape File System. LTFS Library Edition provides the ability to create a single file system mount point for a logical library that is managed by a single instance of LTFS, which is running

on a single computer system. In addition, it provides for caching of tape indexes, and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

For more information about LTFS-SDE, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

3.6.7 Data safe mode

TS1140 supports *data safe mode*. This mode is controlled by the application and prevents inadvertent overwrite. Data safe mode treats the tape volume that is mounted as WORM drive and prevents inadvertent overwrite. This mode is set by the application or host system.

3.6.8 Enhanced Ethernet support

The 3592 Model E07 tape drive includes an Ethernet port for use by an IBM Service Support Representative (SSR) for procedures such as updating microcode, uploading a drive memory dump, or viewing drive status. The Ethernet port on the TS1140 also can be used by the user for providing the capability to access a drive's virtual operator panel and advanced status pages remotely by attaching an Ethernet cable from the drive to the users' network.

Important: The Ethernet function is not supported on TS1140 drives in a TS3500 tape library.

Expanded Ethernet port functionality

The Ethernet port is used in the TS1140 Rack mount configuration when in a TS3500 tape library configuration the TS3500 tape library management interface (MI) can be used to manage the TS1140 instead. Figure 3-14 on page 151 shows the location of the Ethernet port.

3.6.9 TS1140 physical characteristics

The TS1140 tape drive includes an identical form factor and is plug-compatible with existing 3592 models. It maintains low power and improves power management. The maximum continuous operating power increased by 2 watts from the TS1120 because of faster motor speeds and enhanced electronics. The drive power use is 51 watts maximum operating power, as compared to 39 watts for the TS1130. Standby power is fewer than 24 watts.

The TS1140 has a standby cooling management feature, which reduces the fan speed when idle to further reduce power and reduce airborne debris contaminants. The fan operating mode is controlled by a single input signal called *full-speed mode* or *variable-speed mode*. In full-speed mode, the fan or blower runs at full speed. In variable-speed mode, the blower adjusts its speed based on the ambient temperature down to a minimum of about 50% of its full speed.

The speed of the fan is based on the following conditions:

- 3592-E07 drive code enables variable-speed mode under the following conditions:
  - The drive is unloaded and idle for five minutes.
  - The internal temperature is at least 3 degrees below the Full speed required temperature limit.

- The drive code reverts to full-speed mode as soon as the following conditions are met:
  - A cartridge is placed in the loader or loaded.
  - The internal temperature of the drive rises above the Full speed required temperature limit.

The internal temperature sensor is sampled at five-minute intervals.

3592 packaging

As in previous models, the TS1140 tape drive is a canister with a drive that is packaged inside the canister. Unique markings on the front and rear of the canister allow the identification of an E07 from a previous version of the drive. The canister enclosure provides mounting, connections, fiducial labels for calibration, and status LEDs for the use in automation frames.

The canister is mounted in various forms of mounting hardware for use in different automation systems. The drive unit is inside the canister. The 3592-E07 drive has the same physical form factor as the TS1130, TS1120, and 3592-J1A drive. Thus, only the complete canister can be changed or replaced and not the drive alone.

The 3592-E07 canister no longer has an RS-232 serial port. An Ethernet service port was added to the drive, which is for service, and use by the user. It provides the capability for users to access advanced drive status pages and for service personnel to access a drive virtual operator panel and perform firmware uploads and download drive memory dumps. It is a single, standard RJ45 connector at the rear of the canister, as shown in Figure 3-14.

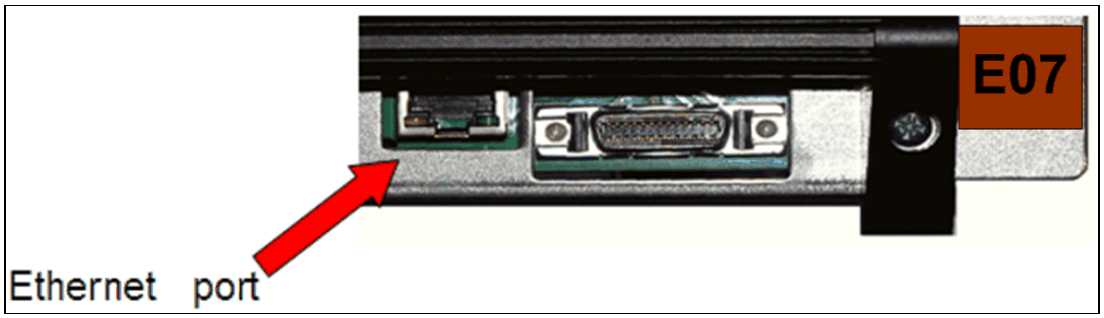


Figure 3-14 TS1140 Ethernet port

Important: This product might not be certified in the country of installation for connection by any means whatsoever to interfaces of public telecommunications networks. Further certification might be required by law before making any such connection. Contact IBM for more information.

Internal hardware enhancements

The TS1140 features the following significant hardware enhancements over the previous models:

- New 32-channel enhanced ECC recording format.
- Enhanced JC-type media servo pattern.
- Flangeless rollers, which are designed to minimize tape edge damage and debris buildup by elimination of the roller flanges.
- Giant Magneto Resistive Heads (GMR head). This advanced high gain head is designed to reduce friction. It has advanced head coating to prevent corrosion and to extend head and tape cartridge life.

- Skew Actuator, which allows dynamic skew adjustment of the head to keep head perpendicular to tape.
- Data-dependent, noise-predictive, maximum-likelihood (DD-NPML) detection scheme was developed at IBM Research, Zurich to enable the accurate detection of data errors.

3.6.10 Upgrade considerations

A drive-field Miscellaneous Equipment Specification (MES) conversion feature is available for a 3592-E06 model to 3592-E07 model conversion to a TS1140. If this method is chosen to replace the TS1130 drive, only the drive changes; the canister remains the same. The model EU6, which was previously upgraded from a model E05, cannot be upgraded to a model E07.

The serial number of the original drive is written by the library to the vital product data (VPD) of the replacement drive. The MES is valid for both the TS3500 tape library and a rack-mounted drive.

3.6.11 Firmware updates

No changes were made to the firmware update mechanisms for the TS1140 compared to TS1130 tape drives:

- All four mechanisms currently supported for microcode updates on the 3592-E06 also provide support on the E07:
- The TS1140 continues to support concurrent Licensed Internal Code load with deferred activation.
- The TS1140 has a single Licensed Internal Code image unique from previous models. A unique LOAD ID and incremented RU name field is assigned for the 3592-E04 drive.

Unique Licensed Internal Code is required for the model E07 drives, because the LOAD ID differs from the LOAD ID that is required for previous versions of 3592. The firmware for the 3592-E07 drive can be updated by using one of the following methods, depending on where the drive is installed:

- Through the host attachment by using the write buffer command
- Through the Ethernet port on the drive
- Through the library RS-422 port to the drive canister (not supported on rack mount)
- Through the use of an FMR cartridge (might not be supported on automation systems)

3.6.12 RAS features

The RAS features are improved or maintained relative to the TS1130. Similar to its predecessor models, the TS1140 is a single FRU, which is hot pluggable without a maintenance window and supports nondisruptive code loading. As with TS1130, there is fan speed management and unique device microcode file management through a LOAD ID. Support is available for a larger service display.

The end-of-life use alert for media becomes activated on full file pass use. The Nearing Media Life alert is given at 19,900 mounts or 295 full-file passes, and the Media Life alert is given at 20,000 mounts or 300 full-file passes.

3.6.13 Improved media SARS

The media SARS function for the TS1140 includes the following improvements:

- Tape alerts are now generated when media passes use life, as determined by full-file passes, meters of tape processed, or write pass count, and the total number of mounts (already supported).
- A media SARS summary is maintained in the cartridge memory in a manner where it can be rebuilt on tape if the SARS records on tape cannot be read and must be reinitialized. This cartridge memory copy also is readable on an earlier level TS1120 drive to preserve SARS information between logical format conversions.

3.6.14 Encryption

The TS1140 tape drive is encryption-capable. Like the TS1130, there is no need to enable the drive explicitly, which was the case with the TS1120 tape drive.

When the drive is installed behind a 3592 C07 or 3592 C06 Tape Controller, it is encryption-enabled as part of the installation, which is a controller requirement.

Encryption on TS1140 includes the following enhancements:

- LME, SME, AME, T10 method support.
- Continued EEDK wrapped key support in LME, SME.
- Enhanced Protocol support: IPP, T10 SPIN and SPOUT, IKEv2 (PGA).
- Enhanced drive cryptographic upgrades to change the default authentication means from SHA-1 to SHA-2 when using IBM Security Key Lifecycle Manager.
- T10 standards-based encryption control on logical block basis (not tied to format identifier), and even write encrypted data and clear data to the same tape cartridge.

3.6.15 Tracking data written

An application can track the following data in KBs:

- The number of logical bytes written
- The number of physical bytes written
- The amount of free space remaining on a volume
- The capacity of the volume
- The number of logical bytes deleted

Now with the 4000 GB tape (non-compressed), the possibility exists with the TS1140 to overflow some of the 4-byte fields that contain these values. Of particular concern is the logical data-related fields that (with compression) deal with an amount of data that might be larger than the physical capacity of the tape. Applications that use, store, and display this type of information might need to account for and determine how best to handle an overflow situation.

3.7 IBM TS1130 tape drive

The IBM TS1130 tape drive (also referred to as the *3592 Model E06 and EU6*) is the third tape drive generation of the IBM 3592 tape family. This generation provides higher capacity and performance compared to the predecessor 3592 Model E05.

The TS1130 records in two recording formats, which support encryption and nonencryption. Enterprise Format 3 (EFMT3) is used to represent the non-encrypted recording format, and Enterprise Encrypted Format 3 (EEFMT3) is used to denote the encrypted recording format.

With these recording formats, the non-compressed capacity of the extended length MEDIA9 and MEDIA10 cartridges is increased from 700 GB to 1 TB. The 3592 Model E06 is downward read compatible (*n*-2) to the 3592 Model J1A format (EFMT1) and is downward write-compatible (*n*-1) to the 3592 Model E05 formats (EFMT2/EEFMT2). All current media types are supported.

Host interfaces to System z and open systems platforms are maintained. The TS1130 tape drive is supported by IBM 3592 Model J70 Tape Controller, the 3592 C06 Tape Controller, the 3592 C07 Tape Controller, and the TS7700 Virtualization Engine that uses 4 GBps dual port fibre cards. It supports integration into the IBM TotalStorage 3494 tape library, the TS3500 tape library, the TS3400 tape library, or racks that enable stand-alone installations. No support is available for the 3494 model B10/B20 Virtual Tape Server. Figure 3-15 shows the front view of the IBM TS1130 tape drive.



Figure 3-15 Front view of the TS1130 tape drive

The TS1130 tape drive maintains the same features and technology enhancements that were introduced with the 3592 Model J1A and extended by the TS1120. In addition, the TS1130 offers several enhancements over the predecessor models, which are described next.

The following features were introduced with the 3592-J1A and 3592-E05:

- Digital speed matching
- Channel calibration
- High-resolution tape directory
- Recursive accumulating backhitchless flush or NVC
- Backhitchless backspace
- SLDC
- Capacity scaling
- Single FRU
- Error detection and reporting
- SARS

- Encryption support
- Dual-stage 16-head actuator
- Offboard data string searching
- Enhanced logic to report logical end of tape

3.7.1 Multiple subsystem and automation support

The 3592-E06 supports all of the same subsystems and automation environments as the previous models. The 3592-E06 and 3592 cartridges support multiple automation libraries and can be easily transported between environments. Table 3-13 summarizes these systems.

Table 3-13 Subsystem support summary

Subsystem	3592-E06	3592-E05	3592-J1A
3494-L22	4 drives per frame	4 drives per frame	4 drives per frame
3494-D22	12 drives per frame	12 drives per frame	12 drives per frame
3584-L23	12 drives per frame	12 drives per frame	12 drives per frame
3583-D23	12 drives per frame	12 drives per frame	12 drives per frame
Support within a frame	Full mix of all models allowed	Full mix of all models allowed	Full mix of all models allowed
Rack-mounted	Supported (12 drives/frame)	Supported (12 drives/frame)	Supported (12 drives/frame)

3.7.2 Media

The following TS1130 tape drive capacity and performance improvements are provided on the existing media:

- The TS1130 tape drive reuses all TS1120-supported media types:
  - MEDIA5: IBM 3592 Enterprise Tape Cartridge
  - MEDIA6: IBM 3592 Enterprise WORM Tape Cartridge
  - MEDIA7: IBM 3592 Economy Tape Cartridge
  - MEDIA8: IBM 3592 Economy WORM Tape Cartridge
  - MEDIA9: IBM 3592 Extended Tape Cartridge
  - MEDIA10: IBM 3592 Extended WORM Tape Cartridge
- The TS1130 improves capacity and performance by writing and reading the E06 logical format by using higher track density and higher linear density on the same media types.
- The TS1130 supports downward reading of 3592-J1A and TS1120 native formats and writing the TS1120 format:
  - *n*-2 for read
  - *n*-1 for read/write
- The appropriate Licensed Internal Code levels that are available for 3592-J1A and TS1120 must be applied that enable the recognition of the E06 format and allow reuse of the media in the older formats. Thus, a model J1A or E05 drive can reformat media that was previously written in the E06 format and write on it in the appropriate format.

Important: This design supports a common scratch pool by media type regardless of the last written format or allocation target drive.

3.7.3 Capacity and performance

Capacity and performance were improved compared to the IBM TS1120 tape drive for all media types and for all formats that the TS1130 reads or writes.

Capacity improvement

The use of the 3592-E06 logical format offers the following capacity improvement:

- A 42% capacity uplift for JB and JX (extended length media) from 700 GB to 1 TB
- A 28% capacity uplift for JA and JW (standard length media) from 500 GB to 640 GB
- A 28% capacity uplift for JJ and JR (economy short media) from 100 GB to 128 GB

Important: Only JB or JX media receive another 14% linear density improvement in the TS1130 format.

Performance improvement

The overall performance is increased by the following improvements:

- Data rate
- Larger buffer
- Better backhitching
- Improved speed matching
- Read ahead
- Faster locate
- Improved communication links

Higher data rates

Performance is improved for the TS1130 up to 60% over the TS1120. When the TS1130 is in TS1120 emulation mode, it has up to 50% improvement over the TS1120 for reads and writes; up to 50% improvement in 3592-J1A emulation mode for reads only.

The following maximum speeds are available for the TS1130:

- The E06 format data rates increase to 160 MBps maximum native and to 360 MBps maximum compressed.
- The E05 format data rates increase to 150 MBps maximum native and to 360 MBps maximum compressed.
- The J1A mode for reads only increase to 70 MBps maximum native and to 360 MBps maximum compressed.

The maximum compressed data rate numbers might be similar for all modes. Table 3-14 summarizes the capacity and performance characteristics.

Table 3-14 Capacity and performance summary

Media	E06 format capacity data rate (minimum–maximum)	E05 format capacity data rate (minimum–maximum)	J1A format capacity data rate (minimum–maximum)
JB, JX	1 TB 40 MBps - 160 MBps	700 GB 40 MBps - 150 MBps	N/A
JA, JW	640 GB 40 MBps - 140 MBps	500 GB 40 MBps - 140 MBps	300 GB (read only) 30 MBps - 70 MBps
JJ, JR	128 GB 40 MBps - 140 MBps	100 GB 40 MBps - 140 MBps	60 GB 30 MBps - 70 MBps

Larger buffer

The main buffer size is increased to 1 GB. This increase improves the drive agility, file access, and small file handling. Furthermore, the buffer reduces backhitches for all workloads and improves overall read/write performance.

Speed matching

The speed matching function is improved on the TS1130 drive because the number of speeds and the range of supported data rates is improved. The following data rate ranges depend on the logical format and the media type used:

- Seven read/write speeds are supported for JB media:
  - For the EFMT3 or EEFMT3 format, the range is 31 MBps - 163 MBps.
  - For the EFMT2 or EEFMT2 format, the range is 29 MBps - 150 MBps.
- Seven read/write speeds are supported for JA media:
  - For EFMT3 or EEFMT3 and EFMT2 or EEFMT2, the range is 27 MBps - 139 MBps.
  - For EFMT1 format, the range is 14 MBps - 70 MBps.

Virtual backhitch

The small file write-synchronize feature is improved. Therefore, a 30 - 50% net data rate improvement can be achieved for the write synchronize workload. For more information about write synchronize, see “Virtual backhitch (nonvolatile caching)” on page 112.

Faster high-speed space/locate

The load times and unload times have been slightly improved. The maximum locate/rewind speed is increased to 12.4 mps. With these enhancements, average first file access time has improved. For more information, see Table 3-15 on page 158.

Increased library interface link speed

For the TS3500 tape library attachment and for the TS3400 tape libraries, the LDI RS-422 interface speed was increased to 922 KBAUD. This change allows faster code downloads and dump uploads from the library. In 3494 tape libraries, the BAUD rate remains at the current operating defaults.

Read Ahead

On sequential reads, the tape drive automatically runs Read Ahead and fills the buffer with data sequentially beyond the target block.

Because of the large data buffer, the 3592-E06 supports Read Ahead of approximately 1000 MB of compressed data from tape. Therefore, for applications that issue many repeating, sequential short-hop locates (skipping over files and reading the file headers, for example), the drive outperforms competitive dervishes that support the Read Ahead feature.

When the drive processes a command to locate or read a block, the drive automatically continues to stream down the tape and read ahead until the data buffer is full. This allows subsequent Locate or Read commands to be fulfilled from the data buffer at faster speeds, rather than requiring access to the tape, which stops and waits for the next command, with this unique functionality.

Performance scaling and segmentation

As with the 3592 Model J1A and the 3592 Model E05, performance scaling and performance segmentation are supported with MEDIA5 and MEDIA9 cartridges on the TS1130. By using the recording formats EFMT3/EEFMT3, a MEDIA5 cartridge can be scaled to 128 GB, and a MEDIA9 cartridge can be performance scaled to 200 GB.

Then with performance segmentation, a MEDIA5 cartridge can be segmented into a 128 GB fast access segment and a 426 GB slower access segment. A MEDIA9 cartridge can be scaled to a 200 GB fast access segment and a 666 GB slower access segment.

Cartridges that are performance-scaled or performance-segmented can be reused (reformatted) to their full capacity, to the performance-scaled capacity, or to the performance segmentation format as indicated through the assigned data class.

Tip: You might not want to make any scaling with JB media because of the inefficient use of capacity. There still is no software available to use any other segment except the first one.

3.7.4 Access performance specifications and drive characteristics

Table 3-15 summarizes the improvements in the access performance, that is, time to first data, block locate time from load point, or random locate times, and the drive characteristics.

Table 3-15 Access performance specifications and drive characteristics

Parameter	3592-E06 EFMT3 or EEFMT3	3592-E05 EFMT2 or EEFMT2	3592-J1A EFMT1
Tape speed, locate/rewind	12.4 mps	10 mps	8 mps
Drive load/ready time	13 s	13 s	19 s
Block locate time from load point average	27 s for JA, JW 11 s for 20% scaled JA, JW 11 s for JJ, JR 36 s for JB, JX 15 s for 20% scaled JB	33 s for JA, JW 11 s for 20% scaled JA/JW 11 s for JJ, JR 45 s for JB, JX 15 s for 20% scaled JB	39 s for JA 11 s for 20% scaled JA
Time to first data average (load/ready + locate)	39 s for JA, JW 24 s for 20% scaled JA, JW 24 s for JJ, JR 48 s for JB, JX 28 s for 20% scaled JB	46 s for JA, JW 24 s for 20% scaled JA, JW 24 s for JJ, JR 58 s for JB, JX 28 s for 20% scaled JB	39 s for JA 11 s for 20% scaled JA
Random block locate time	20s for JA, JW 9 s for 20% scaled JA 27 s for JB, JX 12 s for 20% scaled JB	23 s for JA, JW 10 s for 20% scaled JA 31 s for JB, JX 12 s for 20% scaled JB	27 s for JA 9 s for 20% scaled JA
Unload time	23 s for JA, JW, JR, JJ, JB, JX	23 s for JA, JW, JR, JJ, JB, JX	21 s for JA
Rewind maximum	66 s for JA, JW 18 s for 20% scaled JA 18 s for JJ, JR 90 s for JB, JX 24 s for 20% scaled JB	66 s for JA, JW 18 s for 20% scaled JA 18 s for JJ, JR 90 s for JB, JX 24 s for 20% scaled JB	77 s for JA 18 s for 20% scaled JA
Read/write speed maximum	8.551 mps	6.21 mps	4.74 mps

Parameter	3592-E06 EFMT3 or EEFMT3	3592-E05 EFMT2 or EEFMT2	3592-J1A EFMT1
Number of tracks	1152	896	512
Number of passes (from BOT to EOT)	72	56	64
Linear density	321 kbpi	282 kbpi	282 kbpi
Servo regions	5	5	5
Data tracks recorded simultaneously	16	16	8
Buffer size	1 GB	512 MB	128 MB

3.7.5 Emulation mode

The 3592 model E06 does not support any emulation modes. Because the drive cannot write the J1A logical format, it cannot fully emulate all format behaviors of a TS1120 or 3592-J1A drive.

3.7.6 TS1130 physical characteristics

The TS1130 tape drive comes with an identical form factor and is plug-compatible with existing 3592 models. It maintains low power and improves power management. The maximum continuous operating power increased by 2 watts from the TS1120 because of faster motor speeds, 39 watts drive-only as compared to 37 watts for the TS1120. Also, standby power is fewer than 20 watts.

The TS1130 has a standby cooling management feature, which reduces the fan speed when idle to further reduce power and reduce airborne debris contaminants. The fan operating mode is controlled by a single input signal called *full-speed mode* or *variable-speed mode*.

In full-speed mode, the fan or blower runs at full speed. In variable-speed mode, the blower adjusts its speed based on the ambient temperature down to a minimum of about 50% of its full speed.

The speed of the fan is based on the following conditions:

- 3592-E06 drive code enables variable-speed mode under the following conditions:
  - The drive is unloaded and idle for five minutes.
  - The internal temperature is at least 3 degrees below the “Full speed required” temperature limit.
- The drive code reverts to full-speed mode as soon as the following conditions are met:
  - A cartridge is placed in the loader or loaded.
  - The internal temperature of the drive rises above the “Full speed required” temperature limit.

The internal temperature sensor is sampled at five-minute intervals.

3592 packaging

As in previous models, the TS1130 is a tape drive canister with a drive that is packaged inside the canister. Unique markings on the front and rear of the canister allow the identification of

an E06 from a E05 or J1A drive. The canister enclosure provides mounting, connections, fiducial labels for calibration, and status LEDs for the use in automation frames.

The canister is mounted in various forms of mounting hardware for use in different automation systems. The drive unit is inside the canister. The 3592-E06 drive has the same physical form factor as the TS1120 and 3592-J1A drive. Thus, only the drive can be changed, instead of the complete canister.

The 3592-E06 canister no longer has an RS-232 serial port, which remains if an MES is obtained to change an existing 3592-E05 model to an E06 model. An Ethernet service port was added to the drive, which is used only for service. It is a single, standard RJ45 connector at the rear of the canister that supports only the IPv4 protocol and online service and debug functions to a non-client network. Both features are not available on a TS1120 model that was changed by using an MES.

3.7.7 Upgrade considerations

A drive-field MES conversion feature is available for a 3592-E05 model to 3592-EU6 model conversion to a TS1130. If this method is chosen to replace the TS1120 drive, only the drive changes; the canister remains. This model EU6 is identical to the model E06 with the following exceptions:

- The standby fan speed control feature is not available.
- The drive Ethernet service port is not available.

The serial number of the original drive is written by the library to the VPD of the replacement drive. The MES is valid for the TS3500 tape library, the IBM 3494 tape library, the C20 frame attached to a silo, and a rack-mounted drive.

3.7.8 Firmware updates

The following minimal changes were made to the firmware update mechanisms for the TS1130 with the predecessor models:

- All four mechanisms currently supported for microcode updates on the 3592-E05 also provide support on the E06:
  - Host interface
  - Debug interface
  - Library interface
  - Field microcode replacement (FMR) cartridge
- The TS1130 continues to support concurrent microcode load with deferred activation.
- The TS1130 has a single microcode image unique from previous models. A unique LOAD ID and incremented RU name field is assigned for the 3592-E06 drive.

Unique microcode is required for the model E05 drives because the LOAD ID differs from the LOAD ID that is required for the J1A drives. The firmware for the 3592-E06 drive can be updated by using one of the following methods, depending on where the drive is installed:

- Through the use of an FMR cartridge (might not be supported on automation systems)
- Through the host attachment by using the write buffer command
- Through the RS-422 port to the drive (might not be supported on automation systems)
- Through the RS-232 debug port at the rear of the canister

3.7.9 RAS features

The RAS features are improved or maintained compared to the TS1120. Similar to its predecessor models, the TS1130 is a single FRU, which is hot pluggable without a maintenance window and supports nondisruptive code loading. There is fan speed management and unique device microcode file management through a LOAD ID. Support is available for a larger service display.

The end-of-life use alert for media becomes activated on full file pass use. Nearing Media Life (alert x13) is given at 19,900 mounts or 295 full-file passes, and Media Life (alert x07) is given at 20,000 mounts or 300 full-file passes.

3.7.10 Improved media SARS

The media SARS function for the TS1130 includes the following improvements:

- MIMs and tape alerts are now generated when media passes use life, as determined by full-file passes, meters of tape processed, or write pass count, and the total number of mounts (already supported).
- A media SARS summary is maintained in the cartridge memory in a manner where it can be rebuilt on tape if the SARS records on tape cannot be read and must be reinitialized. This cartridge memory copy also is readable on an earlier level 3592-J1A drive to preserve SARS information between logical format conversions.

3.7.11 Encryption

The TS1130 tape drive is encryption-capable. There is no need to enable the drive explicitly, which was the case with the TS1120 tape drive.

When installed behind a 3592 C06, or 3592 C07 Tape Controller, the drive is encryption-enabled as part of the installation, which is a default controller requirement during installation.

3.7.12 Tracking data written

An application can track the following data in KBs:

- The number of logical bytes written
- The number of physical bytes written
- The amount of free space remaining on a volume
- The capacity of the volume
- The number of logical bytes deleted

With the 1000 GB tape (non-compressed), the possibility exists with the TS1130 to overflow some of the 4-byte fields that contain these values. Of particular concern is the logical data-related fields that (with compression) deal with an amount of data that might be larger than the physical capacity of the tape. Applications that use, store, and display this type of information might need to account for and determine how best to handle an overflow situation.

3.8 IBM TS1120 tape drive

IBM TS1120 tape drive Model E05 is the second generation of the 3592 tape drives. It has the same machine type as the 3592-J1A with the model type of E05 and is for applications that require high capacity and fast access to data across a wide range of environments. The TS1120 tape drive can encrypt data at the drive. For more information about encryption, see 2.2, “Tape encryption overview” on page 67.

The TS1120 tape drive features dual 4 Gbps Fibre Channel interfaces and a native data rate of up to 100 MBps. It also features a native physical capacity of up to 500 GB on the JA cartridge or 700 GB on a JB cartridge. As with the previous 3592-J1A, the 3592-E05 includes an RS-422 library interface port for communication with the TS3500 tape library.

The 3592-E05 has support for attachment to ESCON and FICON channels on System z servers through the following tape subsystems:

- 3592 J70 Tape Controller
- 3592 C06 Tape Controller
- 3592 C07 Tape Controller
- TS7700 Virtualization Engine

> **Important:** TS1120 Model E05 drives can be configured in native E05 mode or J1A Emulation mode. All drives must operate in the same mode behind a given tape subsystem. All drives must be configured in native E05 mode to enable the support of the 3592 Extended Data cartridge (JB media). Encryption-capable and non-encryption-capable drives can be intermixed. However, all drives must be encryption-capable to enable encryption for the TS7700.

- B10 and B20 Virtual Tape Servers (VTSs) (in J1A Emulation mode)

Figure 3-16 shows the front view of the IBM TS1120 tape drive.

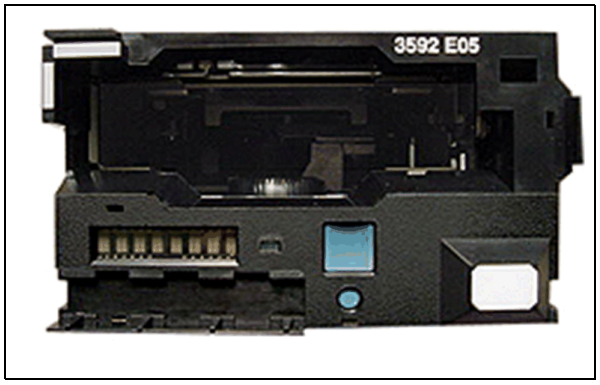


Figure 3-16 TS1120 Model E05

3.8.1 Features for reliability, availability, and performance

The TS1120 tape drive maintains the same form factor and reliability specification of the previous Model 3592-J1A and the features and technology enhancements that were introduced with the 3592 Model J1A. In addition, the 3592-E05 offers several enhancements over the J1A Model.

The following features were introduced with the 3592-J1A and incorporated into the 3592-E05:

- Digital speed matching
- Channel calibration
- High-resolution tape directory
- Recursive Accumulating Backhitchless Flush or NVC
- SLDC
- Capacity scaling
- Single FRU
- Error detection and reporting
- SARS

These features are described in 3.2.4, “Features designed for capacity and performance” on page 111.

To further improve performance and capacity, the TS1120 tape drive offers other enhancements over the 3592 Model J1A. The following sections describe these enhancements. Table 3-15 on page 158 shows a comparison of the 3592-J1A, the TS1120, and the TS1130 tape drive characteristics.

Large internal buffer

The 3592-E05 has a 512 MB internal data buffer compared to the 128 MB maximum on the 3592-J1A. In addition to offering higher performance characteristics, the data buffer offers a read-ahead feature of approximately 500 MB of compressed data from tape.

When the drive processes a command to locate or read a block from tape (in parallel with returning the requested block or locate status to the host), the drive automatically continues to stream down the tape and read ahead until the buffer is full.

With this function, subsequent Locate or Read commands of relatively close proximity blocks can be fulfilled from the data buffer at higher speeds than if access to the tape is required.

Dual-stage, 16-head actuator

The 16-head actuator improves precision head alignment to help support higher track density. The 3592-E05 uses the EFMT2 or E2 recording technology (896 tracks, 16 channels). This technology increases the data capacity of all four cartridge types to 500 GB for types JA and JW and 100 GB for types JR and JJ.

When the IBM Tape Cartridge 3592 Extended Data (JB and JX media type) is used, the data capacity is 700 GB. The 3592-E05 also can read and write in EFMT1 or E1 when emulating the 3592-J1A.

Offboard Data String Searching

The 3592-E05 can search the data content of host records for string matches. This function is called *Offboard Data String Searching* because the data search might be performed offboard from the host. With this feature, the tape drive can search for records on a tape that contains a particular ASCII or EBCDIC character string (1 - 16 bytes in length) at a maximum data rate of 100 MBps.

It takes longer if the host performs this function because the host server needs to read the data, buffer the data to disk, and then parse the data stream with host software routines.

Enhanced logic to report logical end of tape

The 3592-E05 uses enhanced logic to report the LEOT.

The effect of this LEOT function is to reduce the variation in the amount of data recorded before LEOT is issued. Therefore, for applications that use LEOT to stop the write process, a more consistent capacity is recorded to the media.

Encryption support

The IBM TS1120 tape drive provides an option to use drive-based data encryption, which is now standard on all TS1120 tape drives. A chargeable upgrade feature to enable the drive for encryption is available for installed TS1120 tape drives. All 3592 media, including WORM and extended cartridges, can be encrypted. Based on the data class that is defined, the TS1120 tape drive can write in the encrypted or non-encrypted format.

Important: When tape drive encryption is used, all the TS1120 tape drives that are attached to a single 3592 C06 or 3592 C07 Tape Controller must be encryption-enabled.

For more information about encryption, see 2.2.2, “Encryption methods” on page 69.

J1A emulation

With the emulation mode in the 3592-E05, emulation of the previous 3592-J1A Model is possible. When attached to a TS7700 Virtualization Engine, a 3592-J70, or a 3592 C06 Tape Controller in heterogeneous frames containing J1A drives, the 3592-E05 drives automatically operate in J1A Emulation mode in these subsystems.

The same concept is true even when they are set to operate as native E05 drives. When attached to a VTS, the E05 tape drives always operate in J1A Emulation mode. In this mode, the 3592-E05 drives read and write only in E1 format at the J1A performance and capacity ratings. When removed from these subsystems, the drives automatically revert to native E05 operation, and no action is necessary to restore normal mode.

In J1A Emulation mode, the TS1120 cannot be enabled for encryption. It can read and write in a format that is compatible with the 3592 Model J1A tape drive.

The J1A emulation mode includes the following behavior:

- The TS1120 tape drive can read and append to cartridges that are written by the 3592 Model J1A tape drive.
- The TS1120 tape drive can write cartridges in a 3592 Model J1A format that can be read and appended to by the 3592 Model J1A tape drive.
- The TS1120 tape drive cannot read cartridges written by the 3590 or 3490. Cartridges written by the TS1120 tape drive cannot be read by the 3590 or 3490. Even though the cartridges are similar in size, they contain different media and thus are not interchangeable.
- The 3592-J1A cannot read or append to cartridges that were created on a TS1120 tape drive in EFMT2 or EEFMT2 mode.

- The TS1120 tape drive can be attached to the same 3592 Model J70, C06 or C07 Controller, TS7700 Virtualization Engine, or 3494 VTS model B10 or B20 with 3592 Model J1A tape drives. This support is available only when the TS1120 is running in J1A Emulation mode. After TS1120 drives are set to run in E05 native mode, intermix is not supported.

3.8.2 Performance scaling and segmentation

The 3592-E05 provides the same support for performance scaling and segmentation on the JA and JB cartridge as the 3592-J1A does for the JA cartridge. However, the higher density E2 format that is used by the 3592-E05 results in different data capacity for scaled and segmented cartridges than the 3592-J1A.

For example, with the 3592-E05 and EFMT2 format, a JB cartridge can be segmented into a 140 GB fast access segment and a 466 GB slower access segment. Also, a JA cartridge can be scaled to a 100 GB fast access segment and a 330 GB slower access segment.

As with the 3592-J1A, 256 capacity settings are supported on the 3592-E05 drive. Use the following primary settings, which are available as labeled and initialized part-numbered cartridges:

- Full capacity default mode: 500 GB
- 20% scaled fast access mode (capacity scaling setting x'35'): 100 GB
- Performance scaling for 87% capacity (segmented format, capacity scaling setting x'E0')

The tapes then can be scaled back to full capacity as needed.

3.9 IBM TotalStorage Enterprise tape drive 3592 Model J1A

The 3592 Model J1A is the first offering in the 3592 tape drive family that was designed for enterprise applications. Introduced in 2003, this tape drive family provides unprecedented levels of cartridge capacity, performance, and reliability. The 3592 surpasses the capabilities of its predecessors by providing up to five times the capacity and two and-a-half times the data transfer rates of the IBM 3590 series. It can store 300 GB of native capacity and a native data rate of up to 40 MBps. Figure 3-17 shows an IBM TotalStorage Enterprise tape drive 3592 Model J1A.



Figure 3-17 IBM TotalStorage Enterprise tape drive 3592 Model J1A

For its high capacity capability, the 3592 uses the IBM TotalStorage Enterprise Tape Cartridge 3592 (Model 3599), which provides a native cartridge capacity of up to 300 GB. The 3599 media models include the following data cartridges:

- Read/write 300 GB data cartridge
- Read/write Economy 60 GB data cartridge
- WORM 300 GB data cartridge
- WORM Economy 60 GB data cartridge

3.9.1 Characteristics

The first generation of the 3592 family of tape drives outperformed the IBM 3590 family with the following performance and capacity characteristics:

- 40 MBps native streaming data rate
- 300 GB native cartridge capacity
- Dual active FC-2 ports to support enterprise environments that use dual paths for failover or load balancing
- Support of four cartridge types: JA, JJ, JW, and JR
- WORM functionality when operating on one of the two WORM cartridge types, JW or JR
- 128 MB data buffer

3.9.2 Performance scaling

The 3592-J1A drive introduced the support for scaling and segmentation modes on the 300 GB read/write (JA) cartridge only. The following primary settings are used:

- 300 GB default mode
- 60 GB fast access mode (capacity scaled through an `0x35` setting to 20% capacity)

The result of performance scaling to a percentage value (for example, 20%) is that the maximum amount of recordable data is reduced to 60 GB. Also, the average time to locate a random record on a full tape starting from load point is approximately 20% of the time to locate a random record from load point for a full, unscaled tape.

The use of segmentation results in the first segment of 60 GB and a slower access segment of 200 GB of capacity.

4

IBM TS2260 tape drive

The IBM TS2260 tape drive (3580 model H6S) is an external stand-alone or rack mountable unit, which is designed to offer high capacity and performance for the midrange system environment. The TS2260 tape drive incorporates the IBM Linear Tape-Open (LTO) Ultrium 6 Half-High tape drive and uses a dual-port 6 Gbps SAS (serial-attached SCSI) host interface, or, as an option, a single 6 Gbps SAS port and a single USB 3.0 port. The tape drive supports a native data rate performance of up to 160 MBps.

The IBM LTO Ultrium 6 tape drive uses the IBM LTO Ultrium 6 2.5 TB Data Cartridge and provides tape data capacity with up to 6.25 TB with a 2.5:1 compression ratio. IBM Ultrium 6 tape drives can read and write LTO Ultrium 5 data cartridges, and can read LTO Ultrium 4 data cartridges. The TS2260 tape drive supports Write Once Read Many (WORM) on WORM cartridge types.

The Ultrium 6 tape drive is encryption capable and supports application-managed encryption.

The TS2260 tape drive Model H6S uses a 6 Gbps dual port SAS interface for connection to open system servers, or with feature code 5760, an optional single 6 Gbps SAS port and single USB 3.0 port.

The TS2260 tape drive is a client-replaceable unit (CRU). In the case of TS2260 tape drive has a failure, IBM provides a replacement drive.

This chapter includes the following topics:

- Product description
- Half-High Ultrium 6 tape drive
- Media
- Encryption
- Linear Tape File System
- Physical attachment
- Specifications
- Feature codes

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4.1 Product description

The IBM TS2260 tape drive is an external stand-alone or rack mountable unit, and part of the family of IBM Ultrium Tape products. It incorporates the latest generation of the Ultrium 6 Half-High tape drives, which features write cartridges with a native physical capacity of 2.5 TB. The IBM Ultrium 6 technology supports tape partitioning and the IBM Linear Tape File System (LTFS) technology. It also supports encryption of data and Write Once Read Many (WORM) cartridges. For the remainder of this chapter, the terms TS2260 or TS2260 tape drive are used as abbreviations for IBM TS2260 tape drive.

Only one model (model number 3580-H6S) is available for the TS2260 tape drive, as shown in Figure 4-1.



Figure 4-1 Side view of the TS2260 tape drive

The TS2260 tape drive uses 6 Gbps Serial SAS interfaces or an optional single 6 Gbps SAS port and single USB 3.0 port for connecting to servers.

The SAS interfaces are SFF-8088 and the USB interface is a Type B.

An order for the IBM TS2260 (3580 Model H6S) with the USB 3 electronic interface must include the following feature numbers:

- Feature code 5760, USB 3 Conversion Feature
- Feature code 5761, USB 3 2.7m Cable

The TS2260 tape drive is encryption-capable that uses Application Managed Encryption (AME). Encryption is supported on Ultrium 4, Ultrium 5, and Ultrium 6 Data Cartridges. On the tape drive, an encryption LED shows you when the drive is using encryption.

The TS2260 tape drive is a client-replaceable unit (CRU). In the case of TS2260 tape drive has a failure, IBM provides a replacement drive.

For error codes and messages, there is a Single Character Display (SCD) at the front of the TS2260 tape drive.

TS2260 tape drive attaches to selected IBM Power System models, IBM System x, and PC servers. The TS2260 tape drive also supports attachment to other servers that are running Microsoft Windows, HP-UX, Oracle Solaris, and UNIX. For more information about the latest supported servers, see the IBM System Storage Interoperation Center (SSIC) website:

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

In summary, the drive offers the following features:

- Dual port 6 Gbps Serial Attached Small (SAS) Computer Systems Interface
- Single port 6 Gbps SAS port and a single port USB 3.0 host interface.
- Half-High form factor
- Native storage capacity of 2.5 TB per cartridge (6.25 TB at 2.5:1 compression ratio)
- Maximum native data transfer rate of up to 160 MB per second
- Burst data transfer rate of 600 MB per second
- 512 MB read-and-write cache
- Support for encryption on Ultrium 4, Ultrium 5 and Ultrium 6 tape cartridges
- Single Character Display (SCD) operator panel
- Ready, Fault, and Encryption status lights
- Maintenance Mode functions
- Ethernet Port (drive service use only)
- Giant Magneto Resistive (GMR) head with beveled contouring for reducing stiction/friction

4.2 Half-High Ultrium 6 tape drive

The TS2260 tape drive houses the Half-High Ultrium 6 tape drive (as shown in Figure 4-2). The TS2260 is an ideal tape drive for clients with small installations who want a reliable tape drive that uses LTO Ultrium 6 technology. For more information, see 2.4.1, “The IBM LTO Ultrium 6 tape drive range” on page 81.

The TS2260 tape drive features a 6 Gbps SAS or optional USB 3.0 interface for connection to a wide spectrum of open system servers. The LTO Ultrium 6 Tape Media provides partitioning support, which, in conjunction with IBM Linear Tape File System technology, provides the ability to have file-level access to tape data. This support helps quickly locate and update information on the tape media. The IBM Ultrium 6 technology also is designed to support encryption of data. The hardware encryption and decryption core and control core are in the IBM Ultrium 6 tape drive. In addition to reading and writing to Ultrium 6 tape cartridges, the TS2260 tape drive can read and write to Ultrium 5 cartridges and read Ultrium 4 cartridges.

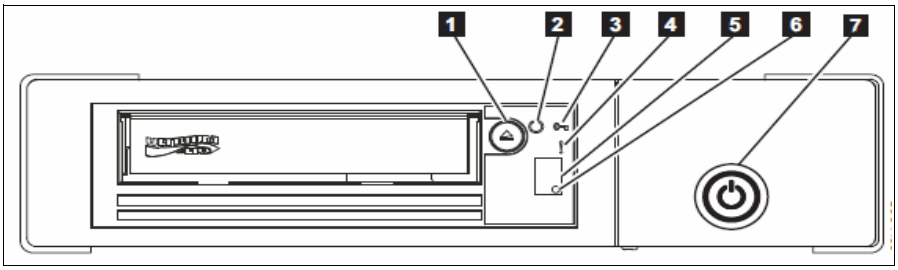


Figure 4-2 Front view of the TS2260 tape drive

The numbers in Figure 4-2 highlight the following components:

1. Cartridge unload button
2. Ready light (green)
3. Encryption light (white)
4. Fault light (amber)
5. Single character display (SCD)
6. SCD dot
7. Power button

4.2.1 Platform support

The value of the TS2260 tape drive can be increased by managing it with tape management solutions, such as IBM Tivoli Storage Manager or other third-party storage software. The following platforms are supported on the TS2260 Tape drive:

- IBM Platforms
  - Selected IBM Power Systems Models:
    - AIX V5.3 TL7 and above
    - i 6.1.1-7.1
  - System x
  - Supported Microsoft and Linux platforms
- Other Vendor Platforms
  - Oracle: Solaris 10 and 11
  - Hewlett Packard: HP-UX 11iV3
  - Microsoft Corporation:
    - Microsoft Windows Server 2008
    - Microsoft Windows Server 2012
  - Linux:
    - Red Hat Advanced Server Enterprise Linux 5.8 - 6.2
    - SUSE Enterprise Server 10 and 11

4.2.2 Performance highlights

If you run applications that are highly dependent on tape processing speed, take advantage of the significant performance improvements that are provided by this tape drive. Table 4-1 shows the performance characteristics of the TS2260 tape drive.

Table 4-1 TS2260 tape drive performance characteristics

Performance characteristics	TS2260 tape drive
Native data rate	160 MBps (with Ultrium 6 media)
Maximum Interface Transfer Rate (maximum sustained with maximally compressible data)	550 MBps (SAS)
Interface Burst transfer rate	600 MBps (SAS)
Nominal load-to-ready time	12 seconds
Nominal unload time	22 seconds
Average rewind time	62 seconds

By using the built-in data compression capability of the tape drive, greater data rates than the native data transfer rate can be achieved.

To improve system performance, the drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower data rate of a server. With speed matching, the drive operates at different speeds when it is reading or writing the Ultrium 5 or Ultrium 6 cartridge format.

Important: Although the TS2260 tape drive provides the capability for excellent tape performance, other components of the system might limit the actual performance that is achieved. The compression technology that is used in the tape drive often can double the amount of data that can be stored on the media. However, the actual degree of compression that is achieved is highly sensitive to the characteristics of the data that is compressed.

4.3 Media

To ensure that the IBM Ultrium tape drive conforms to the IBM specifications for reliability, only IBM LTO Ultrium tape cartridges should be used. Other LTO-certified data cartridges can be used, but they might not meet the standards of reliability that are established by IBM.

4.3.1 Data cartridges

The TS2260 tape drive uses the Ultrium 6 Data Cartridge, which has a native capacity of 2.5 TB. It has a compressed capacity of 6.25 TB with a 2.5:1 compression ratio, and uses a linear, serpentine recording format. The TS2260 tape drive reads and writes data on 2176 tracks, 16 tracks at a time.

The outside of the Ultrium 6 cartridges is black, and the WORM cartridge color is black and silvery gray. The cartridge has a nominal life of 20,000 load and unload cycles.

In Table 4-2, the compatibility of the Ultrium Data Cartridges and tape drives are shown. Ultrium 1, Ultrium 2, and Ultrium 3 Data Cartridges are not supported when Ultrium 6 tape drives are used.

Table 4-2 *Ultrium compatibility among the generations*

IBM Ultrium tape drive	**IBM TotalStorage LTO Ultrium Data Cartridge**					
	2.5 TB (Ultrium 6)	**1.5 TB (Ultrium 5)**	**800 GB (Ultrium 4)**	**400 GB (Ultrium 3)**	**200 GB (Ultrium 2)**	**100 GB (Ultrium 1)**
Ultrium 6	Read/Write	Read/Write	Read only			
Ultrium 5		Read/Write	Read/Write	Read only		
Ultrium 4			Read/Write	Read/Write	Read only	
Ultrium 3				Read/Write	Read/Write	Read only
Ultrium 2					Read/Write	Read/Write
Ultrium 1						Read/Write

4.3.2 Write Once Read Many cartridges

Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a WORM feature is available on IBM LTO Ultrium generation 3, 4, 5, and 6 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and by using a special WORM tape cartridge

A specially formatted WORM tape cartridge is required because standard read/write media are incompatible with the WORM feature. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique CM chip serial number and the unique tape media serial number. For more information about WORM media, see “WORM tape format” on page 47.

4.3.3 Cleaning cartridges

A specially labeled IBM LTO Ultrium Cleaning Cartridge cleans the drive. One cleaning cartridge is included with the shipping package of the TS2260 tape drive.

Important: The drive automatically ejects an expired cleaning cartridge.

For more information, see “Specifications for cleaning cartridges” on page 55.

4.3.4 Cartridge memory

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip, which is a passive contact-less silicon storage device that is physically a part of the cartridge. It holds information about the specific cartridge, the media in the tape drive, and the data on the media.

The LTO-CM enhances the efficiency of the cartridge and aids in determining the reliability of the cartridge by storing data about its age, how many times it was loaded, and how many errors it accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. A cleaning cartridge’s LTO-CM chip tracks the number of times that the cartridge is used to prevent it from being used more than 50 times. The storage capacity of the Ultrium 6 Tape Cartridge Memory Chip is 16320 bytes. Communication between the TS2260 tape drive and the LTO-CM is via a low-level radio frequency field that is transmitted by the drive to the cartridge.

4.4 Encryption

The TS2260 tape drive supports host Application Managed Encryption (AME), which uses T10 protocols. Data encryption is supported with LTO Ultrium 4, Ultrium 5, and Ultrium 6 Data Cartridges only.

The TS2260 tape drive has a white key symbol on the front of the tape drive that indicates the encryption status, as shown in Figure 4-3. It only illuminates when an Ultrium 6 cartridge is loaded and all data on the cartridge is encrypted.

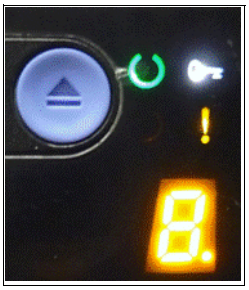


Figure 4-3 Front view of TS2260 showing illuminated encryption symbol

The encryption-enabled drive contains the necessary hardware and firmware to encrypt and decrypt host tape application data. The encryption policy and encryption keys are provided by the host application, and there is no encryption setup required (or available) for this drive.

Encryption requires the latest tape device drivers, which are available on Fix Central:

http://www.ibm.com/support/fixcentral

For more information about tape encryption, see *IBM System Storage Open Systems Tape Encryption Solutions*, SG24-7907.

4.5 Linear Tape File System

IBM Linear Tape File System (LTFS) is the first file system that works with the multiple partitioning that is available on LTO Ultrium 6 and LTO Ultrium 5 tape and brings a new level of use and portability to open systems tape storage. This storage software helps you reduce complexity in data management and access time through the enablement of a self-describing tape that includes a simple file index. It helps to decrease tape, file management, and archive costs while improving response time for new business needs.

LTFS allows files and directories to be shown on the desktop and directory listing and files can be dragged-and-dropped to and from tape. It also supports data exchange and has a simple, one-time installation.

The IBM LTFS SDE Software is included with each TS2260 and uses LTO 6 tape partitioning. It enables a self-describing tape file format and delivers an easy tape storage and distribution solution without the use of more database applications. IBM Linear Tape File System is the perfect solution for those in the Media and Entertainment industry and other fields that need massive data storage on tape for long retention periods, such as banking, scientific research, and government sectors. For more information and list of supported operating systems, see this website:

http://www.ibm.com/tape/ltfs

For more information about LTFS-SDE, see *IBM Linear Tape File System Installation and Configuration*, SG24-8090.

4.6 Physical attachment

The specifications for the physical attachment interface, SAS 6 Gbps, and USB 3.0 are described next.

4.6.1 Serial-attached SCSI

The TS2260 tape drive comes with a dual-port SFF-8088 interface on the back of the drive. For more information about SAS, see “Serial-attached SCSI history” on page 59.

For the latest list of supported adapters, see the System Storage Interoperation Center (SSIC):

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

Figure 4-4 on page 174 shows the rear view of the TS2260 tape drive with a dual-port SFF-8088 interface.

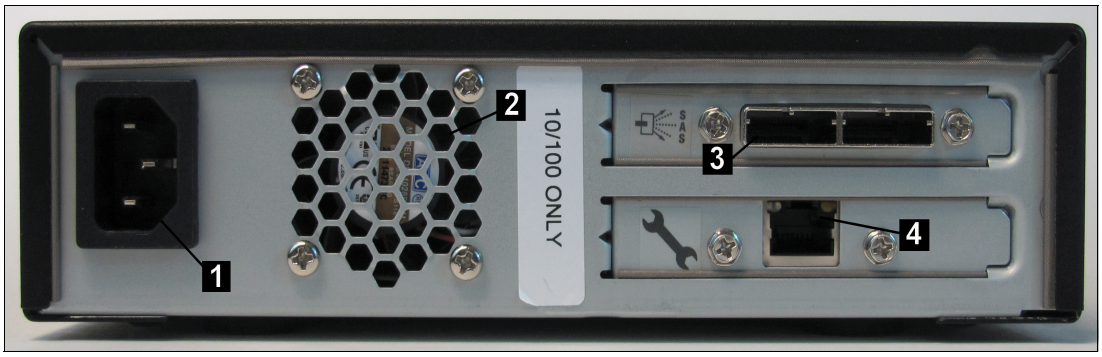


Figure 4-4 Rear view of the TS2260 tape drive

The numbers in Figure 4-4 highlight the following components:

1. Power connector
2. Air vents for fan
3. SAS connector, dual port
4. Ethernet connector (for service only)

4.6.2 Single serial-attached SCSI and USB port

If the optional Feature Code 5760 is ordered, the TS2260 tape drive comes with a single-port SFF-8088 interface and a single port USB 3.0 connector on the back of the drive. For more information about SAS, see “Serial-attached SCSI history” on page 59. The single-port SAS interface supports the same HBAs as the dual-port interface TS2260.

The USB host interface supports USB 3.0 connectivity and can negotiate a Super Speed transfer rate. It also supports USB 2.0 connectivity at the slower transfer rates. The USB interface auto-negotiates speed. There are no configurable topologies, so no feature switches associated with USB. The tape drive with SAS and USB ports requires a device driver for USB 3.0 operation. For the latest list of supported operating systems and configurations, see the System Storage Interoperation Center (SSIC):

`http://www.ibm.com/systems/support/storage/ssic/interoperability.wss`

The latest IBM tape device drivers can be downloaded from IBM Fix Central:

`http://www.ibm.com/support/fixcentral`

Physical characteristics

The drive has a single port, USB 3.0 Type B connector. A USB 3.0 compatible cable is required to connect at the USB 3.0 Super Speed transfer rate.

Figure 4-5 on page 175 shows the rear view of the TS2260 tape drive with a single-port SFF-8088 interface and single USB Type B interface.

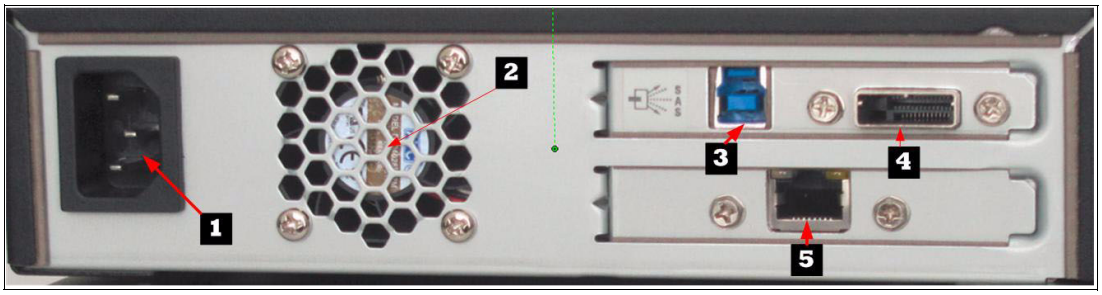


Figure 4-5 TS2260 SAS and USB interface

The numbers in Figure 4-5 highlight the following components:

1. Power connector
2. Air vents for fan
3. USB 3.0 connector
4. SAS connector, single port
5. Ethernet connector (for service only)

4.7 Specifications

This section describes the physical, power, and environmental specifications for the drive.

4.7.1 Physical specifications

Table 4-3 lists the physical specifications for the tape drive.

Table 4-3 Physical specifications

Specification	Measurement
Width	213 mm (8.4 in.)
Length	332 mm (13.1 in.)
Height	58 mm (2.3 in.)
Weight (without a cartridge)	4.3 kg (9.4 lbs.)

4.7.2 Power specifications

Table 4-4 lists the power specifications for the tape drive.

Table 4-4 Power specifications

Power Measurements	Drive
AC line current	100 to 240 V
Line frequency	50 to 60 Hz, auto-ranging
Line current at 100 Vac	1.0 A
Line current at 240 Vac	0.5 A

4.8 Feature codes

Table 4-5 shows the available feature codes for the TS2260 tape drive.

Table 4-5 Feature Code

Feature code	Description
5401	1.0M SAS/Mini-SAS Cable
5402	2.0M SAS/Mini-SAS Cable
5502	2.0M Mini-SAS/Mini-SAS Cable
5760	TS2260 (3580 H6S) Half High Bridgebox - SAS/USB ports
5761	2.7 m USB3 Type A-B cable
7003	Rack Mount Shelf Kit w/PDU Line Cord
8002	Ultrium Cleaning Cartridge
8405	Ultrium 4 Data Cartridges (5-pack)
8505	Ultrium 5 Data Cartridges (5-pack)
8605	Ultrium 6 Data Cartridges (5-pack)
9210	Attached to HP-UX System
9211	Attached to Oracle Solaris System
9212	Attached to Windows System
9215	Attached to Linux System
9400	Attached to IBM i (i5/OS & OS/400®) System
9600	Attached to IBM AIX System
9800-9847	Power cord (different feature code for each country)
9848	Rack Device to PDU Line Cord

5

IBM TS2360 tape drive

The IBM TS2360 tape drive (3580 model S63) is an external stand-alone or rack mountable unit, which offers high capacity and performance for the midrange systems environment. The IBM TS2360 tape drive incorporates the Linear Tape-Open (LTO) IBM Ultrium 6 full Full-High serial-attached SCSI (SAS) tape drive, which provides maximum tape drive throughput and a native data rate performance of up to 160 MBps.

In addition, with the use of the IBM LTO Ultrium 6 2.5 TB Data Cartridge, the TS2360 tape drive provides tape cartridge capacity up to 6.25 TB with a 2.5:1 compression ratio compared to the previous Ultrium 5 1.5 TB (3 TB with a 2:1 compression ratio) tape cartridges. IBM Ultrium 6 tape drives can read and write LTO Ultrium 5 data cartridges, and can read LTO Ultrium 4 data cartridges. The TS2360 tape drive supports Write Once Read Many (WORM) on WORM cartridge types.

The TS2360 tape drive Model S63 uses 6 Gbps serial-attached SCSI (SAS) interfaces and has dual-port Mini-SAS (SFF-8088) interfaces for connecting to open systems servers.

The TS2360 tape drive is encryption-capable and supports Application Managed Encryption (AME).

The TS2360 tape drive is a client-replaceable unit (CRU). In the case of tape drive failure, IBM provides a replacement drive.

This chapter includes the following topics:

- Product description
- Full-High Ultrium 6 tape drive
- Media
- Encryption
- Linear Tape File System
- Physical attachment
- Specifications
- Feature codes

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5.1 Product description

The IBM S2360 tape drive is an external stand-alone or rack mountable unit and part of the family of IBM Ultrium Tape products. It incorporates the latest generation of the Ultrium 6 Full-High SAS tape drives, which write cartridges with a native physical capacity of 2.5 TB. The IBM Ultrium 6 technology supports media partitioning and the IBM Linear Tape File System (LTFS) technology. It also continues to support encryption of data and WORM cartridges. For the remainder of this chapter, the terms TS2360 or TS2360 tape drive are used as abbreviations for IBM S2360 tape drive.

The only model that is available for the TS2360 tape drive is the TS2360 model tape drive S63, which has a SAS interface that has a native data transfer rate of up to 6 Gbps.

Figure 5-1 shows the side view of the TS2360 tape drive.



Figure 5-1 Side view of the TS2360 tape drive

The TS2360 tape drive uses 6 Gbps SAS interfaces for connecting to open systems servers. These interfaces are dual-port Mini-SAS (SFF-8088).

The TS2360 tape drive is encryption-capable and uses Application Managed Encryption (AME).

The TS2360 tape drive is a CRU. In case the TS2360 tape drive has a failure, IBM provides a replacement drive.

For error codes and messages, there is a Single Character Display (SCD) at the front of the TS2360 tape drive.

The TS2360 tape drive attaches to selected IBM Power System Models, IBM System x, and PC servers. The TS2360 tape drive also supports attachment to other servers that are running Microsoft Windows, HP-UX, Oracle Solaris, and UNIX. To determine the latest supported servers, see this website:

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

In summary, the Ultrium 6 tape drive offers the following features:

- Dual-port 6 Gbps Serial Attached Small Computer Systems Interface (SAS)
- Support for WORM on WORM cartridge types
- Native storage capacity of 2.5 TB per cartridge (6.25 TB at 2.5:1 compression ratio) when Ultrium 6 cartridges are used
- Native data transfer rate of up to 160 MB per second
- Burst data transfer rate of 600 MB per second
- 1024 MB read-and-write cache
- Support for encryption of data on Ultrium 4, Ultrium 5, and Ultrium 6 cartridges
- Full-High form factor
- SCD operator panel
- Ready and Fault status lights
- Maintenance Mode functions

5.2 Full-High Ultrium 6 tape drive

The TS2360 tape drive houses the Full-High Ultrium 6 tape drive, as shown in Figure 5-2. The TS2360 is an ideal tape drive for clients who want a robust and reliable tape drive with LTO Ultrium 6 technology. For more information, see 2.4.1, “The IBM LTO Ultrium 6 tape drive range” on page 81.

The TS2360 tape drive features a 6 Gbps SAS interface for connection to a wide spectrum of open systems servers. The LTO Ultrium 6 Tape Media provides partitioning support, which, with IBM Linear Tape File System technology, provides the ability to have file-level access to tape data. This support helps to quickly locate and update information on the tape media. The IBM Ultrium 6 technology also supports encryption of data. The hardware encryption and decryption core and control core are in the IBM Ultrium 6 tape drive. In addition to reading and writing to Ultrium 6 tape cartridges, the TS2360 tape drive can read and write to Ultrium 5 cartridges and read Ultrium 4 cartridges.

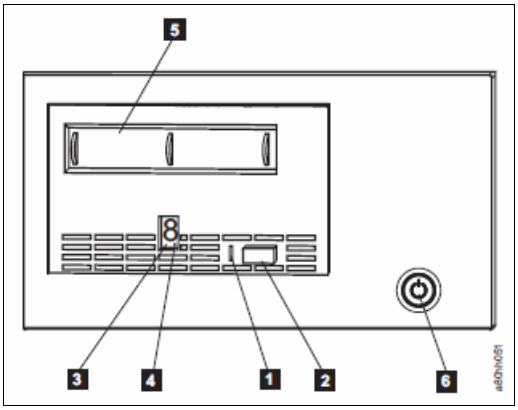


Figure 5-2 Front view of TS2360 tape drive

The numbers in Figure 5-2 on page 179 highlight the following components:

1. Status light
2. Unload button
3. Single character display (SCD)
4. SCD dot
5. Cartridge slot
6. Power button

5.2.1 Platform support

The value of the TS2360 tape drive can be increased by managing it with tape management solutions, such as IBM Tivoli Storage Manager or other, third-party storage software. The following platforms are supported on the TS2360:

- IBM platforms:
  - Selected IBM Power Systems Models
    - AIX V5.3 TL7 and above
    - i 6.1.1-7.1
  - System x
  - Supported Microsoft and Linux platforms
- Other vendor platforms:
  - Oracle: Solaris 10 and 11
  - Hewlett Packard: HP-UX 11iV3
  - Microsoft Corporation:
    - Microsoft Windows Server 2008
    - Microsoft Windows Server 2012
  - Linux:
    - Red Hat Advanced Server Enterprise Linux 5.8 - 6.2
    - SUSE Enterprise Server 10 and 11

5.2.2 Performance highlights

In general terms, Half-High drives are designed for small to medium workload requirements whereas Full-High drives are designed for medium to large workloads. Although the data rates between Half-High and Full-High are the same at 160 MBps, Full-High drives have significantly better times for rewind/locate operations and file access than that of the Half-High equivalent. Full-High drives also provide three times the load/unload life. Therefore, if you run applications that are highly dependent on tape processing speed, take advantage of the significant performance improvements that are provided by this tape drive. Table 5-1 shows the performance characteristics of the TS2360 tape drive.

Table 5-1 TS2360 tape drive Performance characteristics

Performance characteristics	TS2360 tape drive
Native data rate	160 MBps (with Ultrium 6 media)
Maximum Interface Transfer Rate (maximum sustained with maximally compressible data)	550 MBps (SAS)
Interface Burst transfer rate	600 MBps (SAS)
Nominal load-to-ready time	12 seconds
Nominal unload time	17 seconds
Average rewind time	42 seconds

By using the built-in data compression capability of the tape drive, greater data rates than the native data transfer rate can be achieved.

Important: Although the TS2360 tape drive provides the capability for excellent tape performance, other components of the system might limit the actual performance that is achieved. Also, although the compression technology that is used in the tape drive can typically double the amount of data that can be stored on the media, the actual degree of compression that is achieved is highly sensitive to the characteristics of the data that is being compressed.

5.3 Media

To ensure that the IBM Ultrium tape drive conforms to the IBM specifications for reliability, only IBM LTO Ultrium tape cartridges should be used. Other LTO-certified data cartridges can be used, but they might not meet the standards of reliability that are established by IBM.

5.3.1 Data cartridges

The TS2360 tape drive uses the Ultrium 6 Data Cartridge. It has a native capacity of 2.5 TB, and compressed capacity of 6.25 TB with a 2.5:1 compression ratio. It uses a linear, serpentine recording format. The TS2360 tape drive reads and writes data on 2176 tracks, 16 tracks at a time.

The outside of the Ultrium 6 cartridges is black; WORM cartridges are black and silvery gray. The cartridge has a nominal life of 20,000 load and unload cycles.

In Table 5-2, the compatibility of the Ultrium Data Cartridges and tape drives are shown. Ultrium 1, Ultrium 2, and Ultrium 3 Data Cartridges are not supported when Ultrium 6 tape drives are used.

Table 5-2 Ultrium compatibility among the generations

IBM Ultrium tape drive	IBM TotalStorage LTO Ultrium Data Cartridge					
	2.5 TB (Ultrium 6)	**1.5 TB (Ultrium 5)**	**800 GB (Ultrium 4)**	**400 GB (Ultrium 3)**	**200 GB (Ultrium 2)**	**100 GB (Ultrium 1)**
Ultrium 6	Read/Write	Read/Write	Read only			
Ultrium 5		Read/Write	Read/Write	Read only		
Ultrium 4			Read/Write	Read/Write	Read only	
Ultrium 3				Read/Write	Read/Write	Read only
Ultrium 2					Read/Write	Read/Write
Ultrium 1						Read/Write

5.3.2 Write Once Read Many cartridges

Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a WORM feature is available on IBM LTO Ultrium generation 3, 4, 5, and 6 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and by using a special WORM tape cartridge.

A specially formatted WORM tape cartridge is required because standard Read/Write media are incompatible with the WORM feature. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique CM chip serial number and the unique tape media serial number.

For more information about WORM media, see “WORM tape format” on page 47.

5.3.3 Cleaning cartridges

A specially labeled IBM LTO Ultrium Cleaning Cartridge cleans the drive. One cleaning cartridge is included in the shipping package of the TS2360 tape drive.

Important: The drive automatically ejects an expired cleaning cartridge.

For more information about the cleaning cartridge, see “Specifications for cleaning cartridges” on page 55.

5.3.4 Cartridge memory (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip, which is a passive contact-less silicon storage device that is physically a part of the cartridge. It is designed to hold information about specific cartridge, the media in the tape drive and the data on the media.

The LTO-CM enhances the efficiency of the cartridge and aids in determining the reliability of the cartridge by storing data about its age, how many times it was loaded, and how many errors it accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. A cleaning cartridge's LTO-CM chip tracks the number of times that the cartridge is used to prevent it being used more than 50 times. The storage capacity of the Ultrium 6 Tape Cartridge Memory Chip is 16320 bytes. Communication between the TS2360 tape drive and the LTO-CM is via a low-level radio frequency field transmitted by the drive to the cartridge.

5.4 Encryption

The IBM Storage System TS2360 tape drive supports host Application Managed Encryption (AME), which uses T10 encryption protocols. Data encryption is supported with LTO Ultrium 4, Ultrium 5, and Ultrium 6 Data Cartridges only.

The encryption-enabled drive contains the necessary hardware and firmware to encrypt and decrypt host tape application data. The Encryption policy and encryption keys are provided by the host application, and there is no encryption setup required (or available) for this drive.

Encryption requires the latest tape device drivers that are available on the Fix Central download site, which is available at this website:

`http://www.ibm.com/support/fixcentral`

For more information about tape encryption, see *IBM System Storage Open Systems Tape Encryption Solutions*, SG24-7907.

5.5 Linear Tape File System

IBM Linear Tape File System (LTFS) is the first file system that works with the multiple partitioning that is available on LTO Ultrium 6 and LTO Ultrium 5 tape and brings a new level of use and portability to open systems tape storage. This storage software helps you reduce complexity in data management and access time through the enablement of a self-describing

tape that includes a simple file index. It helps to decrease tape, file management, and archive costs while improving response time for new business needs.

LTFS allows files and directories to be shown on desktop and the directory listing and you can drag-and-drop files to and from tape. LTFS also supports data exchange and has a simple one-time installation.

The IBM LTFS SDE software is included with each TS2360 and uses LTO 6 tape partitioning. It enables a self-describing tape file format and delivers an easy tape storage and distribution solution without the use of more database applications. IBM Linear Tape File System is the perfect solution for those in the Media and Entertainment industry and other fields that need massive data storage on tape for long retention periods, such as banking, scientific research, and government sectors. For more information and list of supported operating systems, see this website:

http://www.ibm.com/tape/ltfs

For more information about LTFS-SDE, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

5.6 Physical attachment

The specifications for the physical attachment interface, SAS 6 Gbps, are described next.

5.6.1 Serial attached SCSI

The TS2360 tape drive comes with a dual-port SFF-8088 interface on the back of the drive. For more information about serial-attached SCSI (SAS), see “Serial-attached SCSI history” on page 59. For the latest list of supported adapters, see the System Storage Interoperation Center (SSIC) at this website:

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

Figure 5-3 shows the rear view of the TS2360 t

Note:

Tape drive with a dual-port SFF-8088 interface.

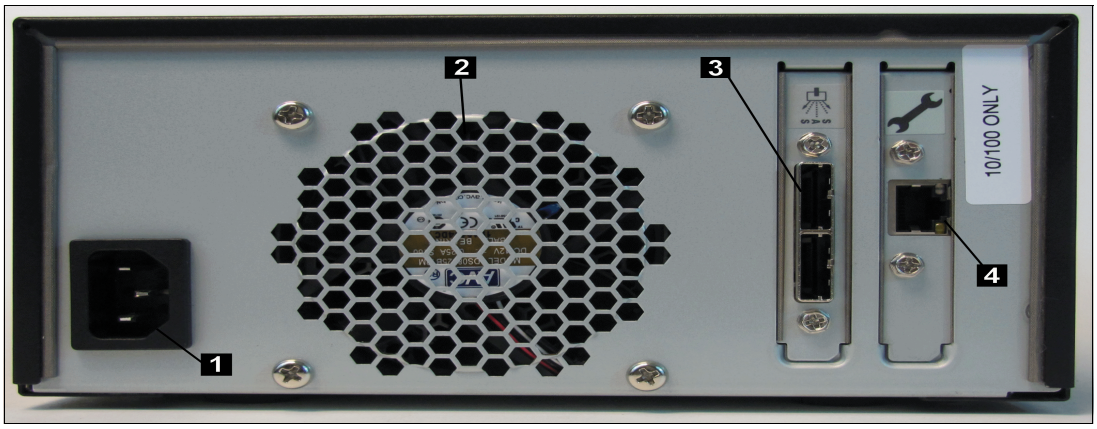


Figure 5-3 Rear view of the TS2360 tape drive

The numbers in Figure 5-3 on page 184 highlight the following components:

1. Power connector
2. Fan
3. Serial attached SCSI connectors
4. Ethernet connector

5.7 Specifications

The following sections describe the physical, power, and environmental specifications for the drive.

5.7.1 Physical specifications

Table 5-3 lists the physical specifications for the tape drive.

Table 5-3 Physical specifications

Specification	Measurement
Width	213 mm (8.4 in.)
Length	332 mm (13.1 in.)
Height	109 mm (4.3 in.)
Weight (without a cartridge)	6.3 kg (13.84 lbs.)

5.7.2 Power specifications

Table 5-4 lists the power specifications for the tape drive.

Table 5-4 Power specifications

Power Measurements	Drive
AC line current	100 to 240 V
Line frequency	50 to 60 Hz, auto-ranging
Line current at 100 Vac	1.0 A
Line current at 240 Vac	0.5 A

5.8 Feature codes

Table 5-5 on page 186 lists the available feature codes for the TS2360 tape drive.

Table 5-5 TS2360 Feature Codes

Feature code	Description
5402	2.0M SAS/Mini-SAS 1x Cable
5502	2.0M Mini-SAS/Mini-SAS 1x Cable
7003	Rack Mount Shelf Kit w/PDU Line Cord
8002	Ultrium Cleaning Cartridge
8405	Ultrium 4 Data Cartridge (5-Pack)
8505	Ultrium 5 Data Cartridge (5-Pack)
8605	Ultrium 6Data Cartridge (5-Pack)
9210	Attached to HP-UX System
9211	Attached to Oracle Solaris System
9212	Attached to Windows System
9215	Attached to Linux System
9400	Attached to i5/OS or OS/400 Systems
9600	Attached to IBM AIX System
9800-9847	Power cord (different feature code for each country)
9848	Rack Device to PDU Line Cord

Part 2

IBM tape libraries for open systems

This part introduces the current IBM tape library models for Linear Tape-Open tape drives, virtual tape libraries, and library management tools and technology.

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6

IBM TS2900 tape autoloader

The IBM TS2900 tape autoloader (Machine Type 3572) provides an efficient, high capacity, low-cost solution for unattended data backup. The library has a compact 1U form factor with easy access to tape cartridges via a removable magazine. The IBM TS2900 tape autoloader is an external stand-alone or rack-mountable unit that incorporates a single Ultrium 4, Ultrium 5, or Ultrium 6 Half-High tape drive. It is equipped with a serial-attached SCSI (SAS) host adapter attachment that has a data transfer rate of up to 6 Gbps.

The IBM TS2900 tape autoloader has a removable cartridge magazine that provides nine data cartridge slots, including a configurable single slot I/O station. IBM TS2900 tape autoloader is an entry point for IBM Linear Tape-Open (LTO) tape automation. This autoloader uses the IBM patented high density (HD) slot technology.

The following features are standard:

- Application-Managed Encryption (AME) with LTO-4, LTO-5 and LTO-6 tape drives
- Bar code reader
- LCD display for local management
- Web User Interface (GUI) for remote management
- Configurable I/O station
- Removable magazine with IBM patented HD Slot technology

The following features are optional:

- Transparent System-Managed Encryption (SME) and Library-Managed Encryption (LME)
- Choice of rack-mount or desktop packaging

For the remainder of this chapter, the terms TS2900 or TS2900 tape autoloader are used as abbreviations for the IBM TS2900 tape autoloader. This chapter includes the following topics:

- Product description
- TS2900 tape autoloader components
- IBM LTO Ultrium Half-High tape drives
- Physical attachments
- Media
- Specifications
- Feature codes

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6.1 Product description

The IBM TS2900 tape autoloader (Machine Type 3572 1U Autoloader) supports one LTO-4, LTO-5, or LTO-6 Half-High tape drive.

The following models are available for the TS2900 tape autoloader:

- The 3572-S6H comes with an Ultrium 6 Half-High tape drive that has a serial-attached SCSI (SAS) interface with a data transfer rate of 6 Gbps. The SAS Ultrium 6 tape drive comes with an SFF-8088 interface. The Ultrium 6 tape drive provides a sustained native data transfer rate of 160 MBps.
- The 3572-S5H comes with an Ultrium 5 Half-High tape drive that has a SAS interface with a data transfer rate of 6 Gbps. The SAS Ultrium 5 tape drive comes with an SFF-8088 interface. The Ultrium 5 tape drive provides a sustained native data transfer rate of 140 MBps.
- The 3572-S4H comes with an Ultrium 4 Half-High tape drive that has a SAS interface, which has a data transfer rate of 6 Gbps. The SAS Ultrium 4 tape drive comes with an SFF-8088 interface. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.

Important: The IBM TS2900 tape autoloader comes ready to be mounted in a standard 19-inch rack. Feature code 7006 must be ordered, which provides the rack mounting hardware. If you want to install the TS2900 tape autoloader as a desk side model, feature code 7010 must be ordered to provide covers.

Figure 6-1 shows the front view of the TS2900 tape autoloader. The cartridge magazine can be seen in the center. The operator control panel is visible on the right side.



Figure 6-1 IBM TS2900 tape autoloader

The following cartridges are supported in the TS2900 tape autoloader:

- IBM LTO Tape Cartridge Ultrium 6 (2.5 TB native physical capacity)
- IBM LTO Tape Cartridge Ultrium 5 (1.5 TB native physical capacity)
- IBM LTO Tape Cartridge Ultrium 4 (800 GB native physical capacity)
- IBM LTO Tape Cartridge Ultrium 3 (400 GB native physical capacity)
- IBM LTO Tape Cartridge Ultrium 2 (200 GB native physical capacity)
- WORM cartridges

Cartridge support is dependent on the tape drive that is installed in the TS2900 tape autoloader.

The library media capacity can be increased by using hardware compression (2:1 compression ratio for Ultrium 5 and below tape drives, and 2.5:1 for Ultrium 6 tape drives).

The TS2900 tape autoloader has a 6 Gbps single-port SFF-8088 SAS connector. This is the same connector for all of the other IBM tape products that support the SAS interface. The tape drive is integrated into the library. There is no tape drive field-replaceable unit (FRU) or client-replaceable unit (CRU) because the entire library is a CRU.

Designed for tape automation, the TS2900 tape autoloader can be attached to the following systems:

- Selected IBM Power Systems models
- IBM System p
- IBM System i
- IBM System x
- IBM System z (Linux for System z)
- AMD
- Hewlett Packard
- Intel x86
- Intel x86_64
- Oracle SPARC

For more information and list of supported operating systems, see this website:

http://www.ibm.com/systems/support/storage/config/ssic/

Depending on which generation of IBM Ultrium tape drive is installed in the TS2900 tape autoloader, the following data cartridges can be used:

- The TS2900 tape autoloader uses the IBM TotalStorage LTO Ultrium 2.5 TB Data Cartridge or 2.5 TB WORM Cartridge when the IBM Ultrium 6 tape drive is installed. The Ultrium 6 tape drive has the capability of writing up to 2.5 TB native capacity and up to 6.25 TB with a 2.5:1 compression ratio. IBM Ultrium 6 tape drives can read and write LTO Ultrium 5 Data Cartridges, read LTO Ultrium 4 Data Cartridges, and do not support earlier LTO Ultrium Data Cartridges.
- The TS2900 tape autoloader uses the IBM TotalStorage LTO Ultrium 1.5 TB Data Cartridge or 1.5 TB WORM Cartridge when the IBM Ultrium 5 tape drive is installed. The Ultrium 5 tape drive has the capability of writing up to 1.5 TB native capacity and up to 3.0 TB with a 2:1 compression ratio. IBM Ultrium 5 tape drives can read and write LTO Ultrium 4 Data Cartridges, read LTO Ultrium 3 Data Cartridges, and do not support earlier LTO Ultrium Data Cartridges.
- The TS2900 tape autoloader uses the IBM TotalStorage LTO Ultrium 800 GB Data Cartridge or 800 GB WORM Cartridge when the IBM Ultrium 4 tape drive is installed. The Ultrium 4 tape drive has the capability of writing up to 800 GB native capacity and up to 1600 GB with a 2:1 compression ratio. IBM Ultrium 4 tape drives can read and write LTO Ultrium 3 Data Cartridges, read LTO Ultrium 2 Data Cartridges, and do not support LTO Ultrium 1 Data Cartridges.

The library has a capacity of a maximum of nine tape cartridges, which provides a maximum media capacity of up to 22.5 TB (56.25 TB with a 2.5:1 compression ratio) data storage.

6.2 TS2900 tape autoloader components

The TS2900 tape autoloader has an improved robotic system that moves along an axis from front to back next to the cartridge magazine. This limited movement provides robust robotics. The standard bar code reader is installed on the picker.

TS2900 tape autoloader houses a cartridge magazine, Operator Control Panel, accessor, library controller card, power supply, and a Half-High tape drive.

Figure 6-2 shows the top view of the TS2900 tape autoloader. The right side of the image is the rear of the library and the left side is the front. The TS2900 tape autoloader is not a modular system and does not allow you to change parts.

.

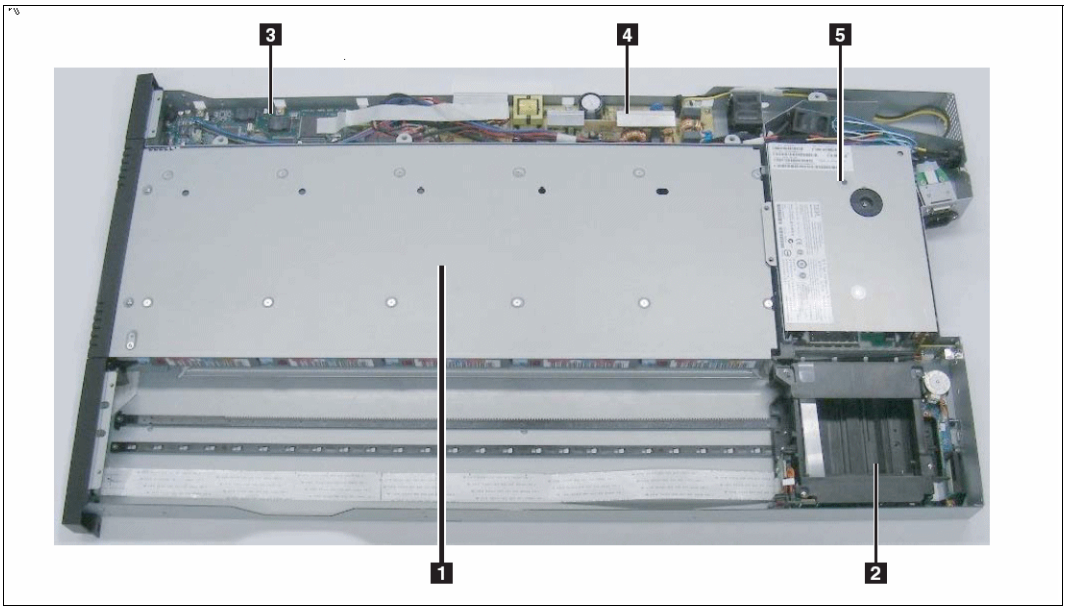


Figure 6-2 Internal top view

The following components are shown in Figure 6-2:

1. Cartridge magazine: The front slot of the first column (far left) in the cartridge magazine can be configured as an I/O station or cleaning slot. The back slot of the first column of the cartridge magazine is used as the exchange slot. The I/O station is used to import and export cartridges without interrupting normal library operation. Cleaning cartridges are used to clean the tape drive heads.
2. Accessor: This component contains the library robot and the bar code reader. The accessor moves cartridges to and from the cartridge magazine.
3. Library control board: The library control board manages the entire library, including the Operator Control Panel and Accessor, and is responsible for monitoring the library to ensure that the library functions properly. It stores vital product data (VPD), such as library settings, the serial number, library logs, and Accessor calibration backup data.
4. Power supply: The power supply is the sole source of power for the library.
5. Tape drive: This library supports the Ultrium 4, Ultrium 5, or Ultrium 6 tape drive. The tape drive in the library is packaged in a container called a *drive sled*. The drive sled is not a CRU.

Important: There is no need to open the top cover of the TS2900 tape autoloader because there are no client serviceable components inside the library. The whole library is a CRU. IBM provides a replacement of the TS2900 tape autoloader in case of defect.

Figure 6-3 shows the components from the rear of the TS2900 tape autoloader.

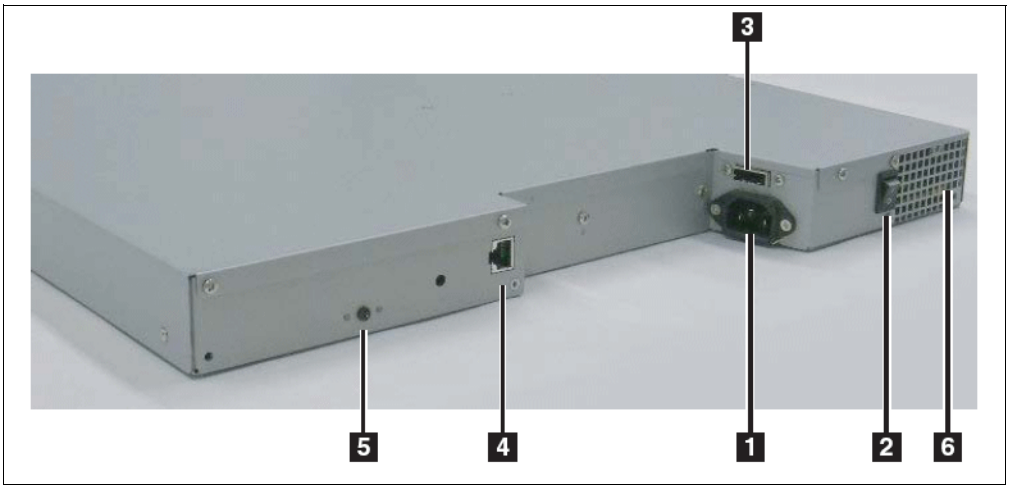


Figure 6-3 Rear panel components

The following components are shown in Figure 6-3:

1. Power connector: The library uses this power connector to connect to a 110/240 Volt AC power supply.
2. Power switch: The library is powered ON when the power supply switch on the rear panel is ON. The library has no independent power switch on the front panel.
3. SAS port: The serial-attached SCSI host interface cable connection. The Ultrium 4, Ultrium 5, and Ultrium 6 SAS drive use the SFF-8088 connection at the drive end and the SFF-8088 or SFF-8470 connection at the host adapter end.
4. Ethernet port: Connects the library to the network using this port.
5. Shipping lock screw: Used to restrain the accessor robot assembly during transportation. Store the shipping lock screw in the storage slot on the rear panel of the library and cover it with the label for future use.
6. Air vent: These vents allow air to escape from the power supply and tape drive sled.

6.2.1 Operator Control Panel

The library is equipped with an Operator Control Panel (OCP) with which you can perform simple actions with the medium changer. By using the OCP interface, you can monitor the medium changer operation, make configuration changes, and perform media access commands.

Important: When a user runs a medium access command through the OCP interface, the medium changer reports Not Ready to Ready status on the SCSI bus.

For more information about the medium changer SCSI command, see *IBM System Storage TS2900 SCSI Reference*, GC27-2211.

The Operator Control Panel interface

The Operator Control Panel (OCP) is on the front of the library and allows users to work locally on the library. The OCP features a monochrome 16-character LCD graphic display. Library operations and service functions are performed from this display.

Figure 6-4 shows the top-level menu tree structure of the OCP on the front of the TS2900 tape autoloader. For more information about all of the OCP functions, see the specification in *IBM System Storage TS2900 Tape Autoloader Setup, Operator, and Service Guide*, GC27-2212.

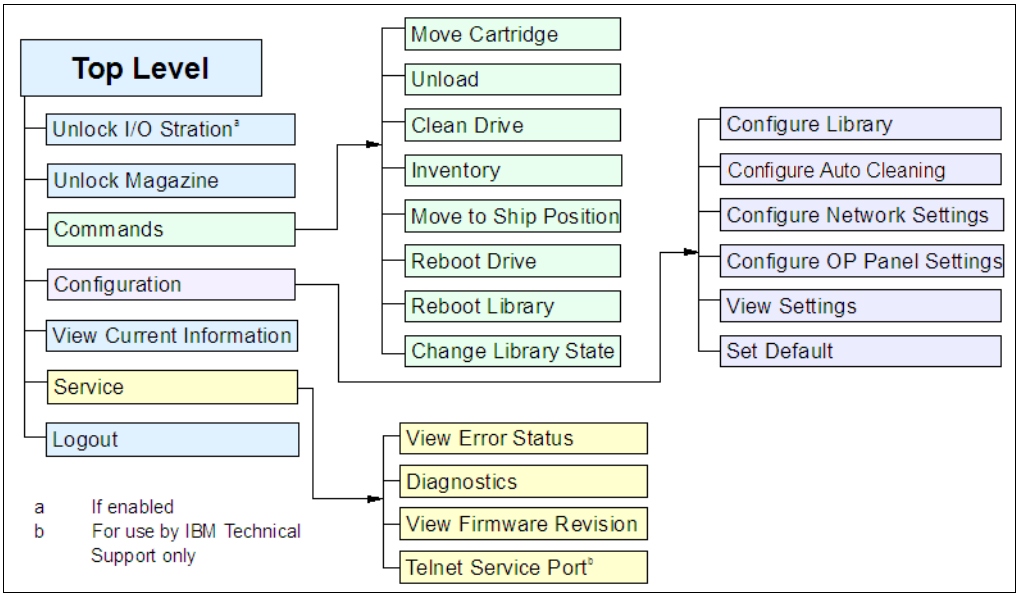


Figure 6-4 Operator control panel menu tree

6.2.2 Robotics

The IBM TS2900 tape autoloader uses an independent tape loader, threader motors, and a positive pin retention. These features help improve the reliability of loading and unloading a cartridge and to retain the pin, even if tension is dropped. An independent loader motor, coupled with the positive pin retention, threads the tape with a higher level of reliability.

6.2.3 Bar code reader

The bar code reader is an integral part of the library Accessor. It reads each cartridge bar code label and the fiducial labels, which identify the types of cartridge magazines and tape drive that are installed in the library, and provides inventory feedback to the host application, OCP, and web User Interface. The library stores the customized inventory data in memory. Library firmware supports a 6 or 8-character volume serial number (VOLSER) on the bar code label on the tape cartridge.

6.2.4 Cartridge storage

The TS2900 tape autoloader has one removable magazine with 10 cartridge slots. The slots are organized as five High Density (HD) slots (2 x 5 = 10), but one of the ten slots is reserved for library swap space, so the magazine has a total user capacity of nine cartridges. If a dedicated I/O slot is defined, the magazine has a capacity of eight cartridges.

When the magazines are filled with cartridges, the web User Interface (UI) can be used to log in to the TS2900 tape autoloader to look at which cartridges are stored and in which storage slot location, as shown in Figure 6-5.

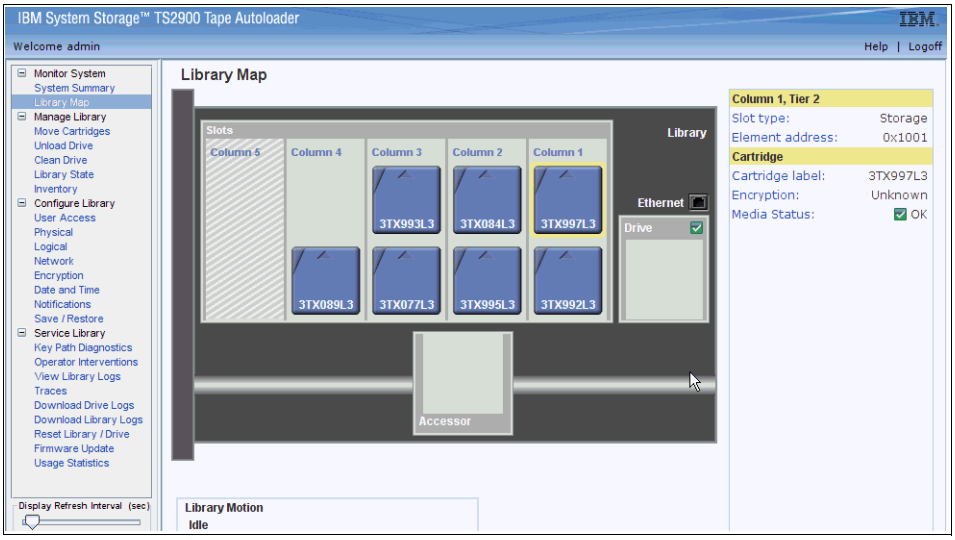


Figure 6-5 Inventory of the magazine

The left part of the magazine is the I/O station and it can be opened by using the Operator Control Panel.

6.3 IBM LTO Ultrium Half-High tape drives

TS2900 tape autoloader houses the LTO-6 HH tape drive, LTO-5 HH tape drive, or the LTO-4 HH tape drive. In this section, we describe several of the highlights of the Half-High Ultrium 6 tape drive. The TS2900 tape autoloader is an ideal tape autoloader for clients who want to have a reliable tape library with LTO technology.

Important: For more information about the LTO 5 and LTO 4 Half-High tape drives, see “IBM LTO Ultrium 5 Half-High library drives” on page 92 and “IBM LTO Ultrium 4 Half-High library drives” on page 98.

6.3.1 LTO-6 Half-High tape drive

In the following topics, we describe the characteristics of the LTO-6 Half-High tape drive. For more information, see 2.4.1, “The IBM LTO Ultrium 6 tape drive range” on page 81.

Platform support

The value of the TS2900 tape autoloader can be increased by managing it with tape management solutions, such as IBM Tivoli Storage Manager or other, third-party, storage software. The following platforms are supported for the TS2900 tape autoloader:

- IBM platforms
  - Selected IBM Power Systems models:
    - AIX V5.3 TL7 and above
    - i 6.1.1-7.1
  - System p
  - System i
  - System x
  - Supported Microsoft and Linux platforms
- Other vendor platforms:
  - Oracle: Solaris 10 and 11
  - Hewlett Packard: HP-UX 11iV3
  - Microsoft Corporation:
    - Microsoft Windows Server 2008
    - Microsoft Windows Server 2012
  - Linux:
    - Red Hat Advanced Server Enterprise Linux 5.8 - 6.2
    - SUSE Enterprise Server 10 and 11

Performance highlights

The TS2900 tape autoloader incorporates the sixth-generation of IBM Half-High Ultrium 6 tape drive technology. The maximum tape drive throughput data rate is up to 160 MBps of native data. Data tracks are written 16 at a time and there are 2176 data tracks in Ultrium 6.

Important: Although the TS2900 tape autoloader provides the capability for excellent tape performance, other components of the system might limit the actual performance that is achieved. Also, although the compression technology that is used in the tape drive can typically double the amount of data that can be stored on the media, the actual degree of compression that is achieved is highly sensitive to the characteristics of the data that is being compressed.

The drive uses a technique called *dynamic speed matching* to adjust the tape drive native data rate as closely as possible to the net host data rate (after data compressibility is factored out). With speed matching, the drive operates at different speeds when it is reading or writing the Ultrium 5 or Ultrium 6 cartridge format.

For more information about LTO-6 Half-High tape drives, see “IBM LTO Ultrium 6 library drives” on page 84.

6.3.2 Encryption

The IBM TS2900 tape library supports data encryption with LTO 6 Half-High SAS tape drives. The following modes of encryption are supported:

- System Managed (available for AIX, Linux, Solaris, and Windows)
- Library Managed (available for OS/400, i5/OS, AIX, Linux, HP-UX, Solaris, and Windows)
- Application Managed (IBM Tivoli Storage Manager)

For LTO Ultrium 6, the Transparent LTO encryption feature is required for enabling encryption. The IBM Security Key Lifecycle Manager is required for enabling System Managed and Library Managed encryption.

The installation of an Ultrium 6 tape drive with encryption might require code updates for IBM Power Systems and supported open systems devices drivers or storage management software. An update of the open systems device drivers can be obtained from the Fix Central download portal at this website:

http://www.ibm.com/support/fixcentral

For more information about Encryption, see 2.2.3, “LTO Ultrium tape encryption” on page 71.

6.3.3 Linear Tape File System

The TS2900 Models S6H and S5H support IBM Linear Tape File System (LTFS) Library Edition and IBM LTFS Storage Manager software.

IBM LTFS provides a software to manage, monitor, archive, and restore files. LTFS is the first file system that works with the multiple partitioning that is available on LTO Ultrium 6 and LTO Ultrium 5 tapes drives and brings a new level of use and portability to open systems tape storage.

This storage software helps to reduce complexity in data management and access time through the enablement of a self-describing tape that includes a simple file index. LTFS allows files and directories to be shown on the desktop, directory listing, and drag-and-drop file to and from tape. It also supports data exchange and has a simple, one-time installation.

IBM LTFS LE allows the TS2900 Autoloader to be mounted and viewed as a single file system with the individual tape cartridge viewed as subdirectories within the file system. It is the perfect solution for those in the Media and Entertainment industry and other fields that need massive data storage on tape for on retention periods, such as banking, scientific research, and government sectors.

IBM LTFS Storage Manager Edition provides storage lifecycle management of (multimedia) files and resource management by using IBM LTFS LE, which reduces digital content archive software licensing costs while reducing video tape cartridge costs. LTFS Storage Manager provides a tool that can use metadata to arrange, search, and manage files at the user’s convenience according to the policies they decide.

For more information about LTFS LE, see this website:

http://www.ibm.com/tape/ltfs

For more information about LTFS, see *Linear Tape File System: Installation and Configuration*, SG24-8090.

6.3.4 Notifications

The TS3200 has the following options available for sending notifications to the host:

- Simple Mail Transfer Protocol

  Simple Mail Transfer Protocol (SMTP), automatically sends an email that contains event information to the email addresses that are specified whenever an event of a certain level occurs.

- Simple Network Management Protocol

  Simple Network Management Protocol (SNMP) is a set of protocols for managing complex networks. SNMP works by sending messages called protocol data units (PDUs) to various parts of a network. Agents, which are SNMP-compliant devices, store data about themselves in Management Information Bases (MIBs) and return this data to the SNMP requesters, such as the host's monitoring application.

6.4 Physical attachments

The TS2900 tape autoloader is only available with a serial-attached SCSI (SAS) interface that has a data rate of 6 Gbps.

6.4.1 SAS interface

The SAS Half-High tape drives that are installed into the TS2900 tape autoloader come with one SFF-8088 interface on the back of the tape drive. For more information about SAS, see "Serial-attached SCSI history" on page 59.

Verify that the HBA of your server is supported. Check the IBM interoperability matrix at the System Storage Interoperation Center (SSIC) page at this website:

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

Figure 6-6 shows the back of the SAS Half-High tape drive with one SFF-8088 interface.



Figure 6-6 Back side of the SAS Half-High tape drive

6.5 Media

To ensure that the IBM Ultrium tape drive conforms to the IBM specifications for reliability, only IBM LTO Ultrium tape cartridges should be used. Other LTO-certified data cartridges can be used, but they might not meet the standards of reliability that are established by IBM.

6.5.1 Data cartridges

The TS2900 tape autoloader with LTO-6 Half-High tape drives uses the Ultrium 6 Data Cartridge. It has a native capacity of 2.5 TB, and compressed capacity of 6.25 TB with a 2.5:1 compression ratio. It uses a linear, serpentine recording format.

Table 6-1 shows the compatibility matrix among the six types of Ultrium cartridges. The generations Ultrium 3, Ultrium 2, and Ultrium 1 are not supported with LTO-6 tape drives.

Table 6-1 Ultrium data cartridge compatibility

IBM Ultrium tape drive	IBM TotalStorage LTO Ultrium Data Cartridge					
	2.5 TB (Ultrium 6)	**1.5 TB (Ultrium 5)**	**800 GB (Ultrium 4)**	**400 GB (Ultrium 3)**	**200 GB (Ultrium 2)**	**100 GB (Ultrium 1)**
Ultrium 6	Read/Write	Read/Write	Read only			
Ultrium 5		Read/Write	Read/Write	Read only		
Ultrium 4			Read/Write	Read/Write	Read only	
Ultrium 3				Read/Write	Read/Write	Read only
Ultrium 2					Read/Write	Read/Write
Ultrium 1						Read/Write

6.5.2 Write Once Read Many cartridges

Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a WORM feature is available on IBM LTO Ultrium generation 3, 4, 5, and 6 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and by using a special WORM tape cartridge.

A specially formatted WORM tape cartridge is required because standard Read/Write media are incompatible with the WORM feature. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique Cartridge Memory (CM) chip serial number and the unique tape media serial number.

For more information about WORM media, see “WORM tape format” on page 47.

6.5.3 Cleaning cartridges

A specially labeled IBM LTO Universal Ultrium Cleaning Cartridge cleans the drive in your library. The drive determines when it needs to be cleaned and notifies the library. When notified, the library indicates that the drive needs cleaning by turning on the Clean Drive LED on the front panel of the library and posting a message on the library display.

The TS2900 tape autoloader supports automatic cleaning and manual cleaning. The library also can be configured for dedicated cleaning cartridge slots, which is achieved by reducing the number of active slots. A reserved slot is not accessible to any host application. In fact, the host has no knowledge that the slot even exists. A reserved slot that contains a cleaning cartridge is referred to as a *dedicated cleaning slot*. These slots can be used for automatic cleaning or for manual cleaning. To remove a cleaning cartridge, move it to the I/O slot.

The IBM Cleaning Cartridges are valid for 50 uses. The cartridge's LTO-CM chip tracks the number of times that the cartridge is used.

For more information about Cleaning Cartridges, see "Specifications for cleaning cartridges" on page 55.

6.5.4 Cartridge Memory chip

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), and statistical information about the cartridge's use.

The LTO-CM also helps determine the reliability of the cartridge by storing data about its age, how many times it was loaded, and how many errors it accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the Ultrium 6 Tape Cartridge Memory Chip is 16320 bytes.

For more information about the LTO-CM, see "Cartridge memory" on page 52.

6.6 Specifications

The technical specifications of the TS2900 are described next.

6.6.1 Physical specifications

Table 6-2 lists the physical specifications for the TS2900 tape autoloader.

Table 6-2 Physical specifications

Parameter	Measurement
Front panel width (chassis/bezel)	445 mm (17.52 in.)/483 mm (19.02 in.)
Depth	850 mm (33.3 in.)
Height	43.6 mm (1.7 in.)
Weight (library only)	13 kg (28.66 lbs)

6.6.2 Power specifications

Table 6-3 lists the power specifications for the tape autoloader.

Table 6-3 Power specifications

Parameter	Measurement
Voltage	100 to 240 Vac.
Frequency	50 to 60 Hz
Power consumption	110 W

6.7 Feature codes

Table 6-4 lists the available feature codes for the TS2900 tape autoloader.

Table 6-4 Feature Code

Feature Code	Description
5402	2.0 m SAS/Mini-SAS 1x Cable
5502	2.0 m Mini-SAS/Mini-SAS 1x Cable
5901	Transparent LTO Encryption
7006	3572 Rack Mount Kit with Device to PDU line cord
7010	3572 Deskside Covers
7703	OEM - No IBM Logo
8002	Ultrium Cleaning Cartridge L1 UCC
8067	TAA Compliant
8111	3572 Additional Magazine
8405	Ultrium 4 Data Cartridges (5-pack)
8505	Ultrium 5 Data Cartridges (5-Pack)
8605	Ultrium 6 Data Cartridge (5-Pack)
9210	Attached to HP-UX System
9211	Attached to Oracle Solaris System
9212	Attached to Windows System
9215	Attached to Linux System
9400	Attached to i5/OS or IBM OS/400 System
9600	Attached to AIX System
9800-9847	Power cord (different feature code for each country)

For more information, see the TS2900 tape autoloader Model website at:

http://www.ibm.com/systems/storage/tape/ts2900/index.html

7

IBM TS3100 tape library

The IBM TS3100 tape library (Machine Type 3573, Model L2U) is a single or dual drive entry-level desktop or a rack-mounted unit that can operate in random or sequential mode. The robotics inside the library move the cartridges to and from the tape drive, which permits unattended backup. Two removable magazines can store a total of 24 cartridges. A single dedicated mail slot (I/O station) is available for importing and exporting cartridges.

The IBM TS3100 tape library incorporates the IBM Linear Tape-Open (LTO) Half-High and Full-High 6 Gbps serial-attached SCSI (SAS) and 8 Gbps Fibre Channel (FC) drives. Mixed Ultrium generations and attachment tape-drive types are supported where drive space is available.

The following tape drives are available for the IBM TS3100 tape library:

- Ultrium 6 Full-High 8 Gbps FC
- Ultrium 6 Half-High 6 Gbps SAS
- Ultrium 6 Half-High 8 Gbps FC
- Ultrium 5 Full-High 6 Gbps SAS
- Ultrium 5 Full-High 8 Gbps FC
- Ultrium 5 Half-High 6 Gbps SAS
- Ultrium 5 Half-High 8 Gbps FC
- Ultrium 4 Full-High 3 Gbps SAS
- Ultrium 4 Full-High 4 Gbps FC
- Ultrium 4 Half-High 6 Gbps SAS (V2)
- Ultrium 4 Half-High 8 Gbps FC (V2)
- Ultrium 4 Full-High Low Voltage Differential (LVD) SCSI

Up to two Half-High IBM Ultrium 3, Ultrium 4, Ultrium 5, and Ultrium 6 tape drives or one Full-High IBM Ultrium 4, Ultrium 5, and Ultrium 6 tape drives can be installed in the TS3100 tape library.

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Tape encryption is supported on the IBM Ultrium LTO-4, LTO-5, and LTO-6 tape drives with the SAS and Fibre Channel interface. The IBM TS3100 tape library supports application-managed encryption (AME), system-managed encryption (SME), and library-managed encryption (LME).

The tape library has four indicator LEDs and one LCD on the front. The LEDs are use to indicate ready/activity, use cleaning tape, media attention, and errors.

Standard features are a bar code reader and a Remote Management Unit (RMU). In this chapter, the terms *RMU* and *web user interface* are used interchangeably.

This chapter includes the following sections:

- Product description
- TS3100 tape library components
- IBM LTO Ultrium tape drives
- Physical attachments
- Media
- Specifications
- Feature codes

For the remainder of this chapter, we use the terms TS3100 or TS3100 tape l*ibrary* as abbreviations for the IBM TS3100 tape library.

7.1 Product description

The IBM TS3100 tape library (Machine Type 3573, Model L2U) supports one LTO-4, LTO-5, or LTO-6 Full-High tape drive or two LTO-4, LTO-5, or LTO-6 Half-High tape drives.

Figure 7-1 shows the front view of the TS3100 tape library. The left and right sections hold the cartridge magazines. The I/O slot is accessible on the lower left side.



Figure 7-1 IBM TS3100 tape library

IBM Ultrium 4, Ultrium 5, and Ultrium 6 LTO tape drives with an FC or SAS interface are encryption capable. The TS3100 tape library-supported encryption methods are AME, SME, and LME.

Depending on the IBM Ultrium tape drive that is installed in the TS3100 tape library, the following data cartridges can be used:

- The TS3100 tape library uses the IBM TotalStorage LTO Ultrium 2.5 TB Data Cartridge or 2.5 TB Write Once Read Many (WORM) cartridge when the IBM Ultrium 6 tape drive is installed. The Ultrium 6 tape drive has the capability of writing up to 2.5 TB native capacity and up to 6.25 TB with a 2.5:1 compression ratio. IBM Ultrium 6 tape drives can read and

write LTO Ultrium 5 Data Cartridges, read Ultrium 4 Data Cartridges, and do not support Ultrium 3, Ultrium 2, and Ultrium 1 Data Cartridges.

- The TS3100 tape library uses the IBM TotalStorage LTO Ultrium 1.5 TB Data Cartridge or 1.5 TB Write Once Read Many (WORM) cartridge when the IBM Ultrium 5 tape drive is installed. The Ultrium 5 tape drive has the capability of writing up to 1.5 TB native capacity and up to 3.0 TB with a 2:1 compression ratio. IBM Ultrium 5 tape drives can read and write LTO Ultrium 4 Data Cartridges, read Ultrium 3 Data Cartridges, and do not support Ultrium 1 and Ultrium 2 Data Cartridges.
- The TS3100 tape library uses the IBM TotalStorage LTO Ultrium 800 GB Data Cartridge or 800 GB WORM Cartridge when the IBM Ultrium 4 tape drive is installed. The Ultrium 4 tape drive has the capability of writing up to 800 GB native capacity and up to 1.6 TB with a 2:1 compression ratio. IBM Ultrium 4 tape drives can read and write LTO Ultrium 3 Data Cartridges, read Ultrium 2 Data Cartridges, and do not support Ultrium 1 Data Cartridges.

The library capacity is 24 tape cartridges, which provide a media capacity of up to 60 TB (150 TB with a 2.5:1 compression ratio) data storage per TS3100 tape library with LTO Ultrium 6 tape drives. Table 7-1 shows the library's storage capacity and data transfer rate.

Table 7-1 TS3100 tape library storage capacity and data transfer rate

Characteristics	2U library specification
Maximum storage capacity: Ultrium 6 Data Cartridges	► 24 data cartridges ► Native: 60 TB ► Compressed: 150 TB (a 2.5:1 compression ratio)
Maximum storage capacity: Ultrium 5 Data Cartridges	► 24 data cartridges ► Native: 36 TB ► Compressed: 72 TB (a 2:1 compression ratio)
Maximum storage capacity: Ultrium 4 Data Cartridges	► 24 data cartridges ► Native: 19.2 TB ► Compressed: 38.4 TB (a 2:1 compression ratio)
Maximum burst data transfer rate	► SAS: 600 MBps ► Fibre Channel: 800 MBps

Depending on the way that the TS3100 tape library is ordered, the required number of tape drives and drive types are specified through feature codes.

7.1.1 TS3100 tape library Ultrium 6 models

The following models are available for the TS3100 tape library:

- The 3573-L2U FC8344 specifies an IBM Ultrium 6 Full-High Fibre Channel tape drive. The Ultrium 6 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 6 tape drive has a native data transfer rate of 160 MBps.
- The 3573-L2U FC8347 specifies an IBM Ultrium 6 Half-High tape drive that has a SAS interface and has a native data transfer rate of up to 6 Gbps. The SAS Ultrium 6 tape drive comes with dual-port SFF-8088 interfaces. The Ultrium 6 tape drive provides a sustained native data transfer rate of 160 MBps.
- The 3573-L2U FC8348 specifies an IBM Ultrium 6 Half-High Fibre Channel tape drive. The Ultrium 6 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 6 tape drive has a native data transfer rate of 160 MBps.

7.1.2 TS3100 tape library Ultrium 5 models

The following models are available for the TS3100 tape library:

- The 3573-L2U FC8244 specifies an IBM Ultrium 5 Full-High Fibre Channel tape drive. The Ultrium 5 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 5 tape drive has a native data transfer rate of 140 MBps.
- The 3573-L2U FC8245 specifies an IBM Ultrium 5 Full-High tape drive that has a SAS 6 Gbps interface. The SAS Ultrium 5 tape drive comes with dual-port Mini-SAS (SFF-8088) interfaces. The Ultrium 5 tape drive provides a sustained native data transfer rate of 140 MBps.
- The 3573-L2U FC8247 specifies an IBM Ultrium 5 Half-High tape drive that has a SAS 6 Gbps interface. The SAS Ultrium 5 tape drive comes with dual-port SFF-8088 interfaces. The Ultrium 5 tape drive provides a sustained native data transfer rate of 140 MBps.
- The 3573-L2U FC8248 specifies an IBM Ultrium 5 Half-High Fibre Channel tape drive. The Ultrium 5 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 5 tape drive has a native data transfer rate of 140 MBps.

7.1.3 TS3100 tape library Ultrium 4 models

The following models are available for the TS3100 tape library:

- The 3573-L2U FC8143 specifies an IBM Ultrium 4 Full-High LVD SCSI tape drive. The Ultrium 4 LVD SCSI drive has an LVD Ultra 160 SCSI that can be connected to LVD Fast Wide adapters. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.
- The 3573-L2U FC8144 specifies an IBM Ultrium 4 Full-High tape drive with a 4 Gbps Fibre Channel interface. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.
- The 3573-L2U FC8145 specifies an IBM Ultrium 4 Full-High tape drive that has a SAS 3 Gbps interface. The SAS Ultrium 4 tape drive comes with an SFF-8088 interface. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.
- The 3573-L2U FC8148 specifies an IBM Ultrium 4 Half-High tape drive (V2). The Ultrium 4 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.
- The 3573-L2U FC8149 specifies an IBM Ultrium 4 Half-High tape drive (V2) that has a SAS 6 Gbps interface. The SAS Ultrium 4 tape drive comes with dual-port SFF-8088 interfaces. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.

7.2 TS3100 tape library components

The TS3100 tape library has an improved robotic system that moves along an axis from front to back between the two cartridge magazines. This limited movement provides robust robotics. The standard bar code reader is installed on the accessor.

Figure 7-2 shows the top view of the TS3100 tape library.

Important: Figure 7-2 is for reference only. The customer is not authorized to remove the top cover of the library. No customer-serviceable components are inside the library. All customer-replaceable units (CRU) can be removed via the rear panel of the library.

The right side is the rear of the library, and the left side is the front of the library. The TS3100 tape library is a modular system so that you can change parts easily.

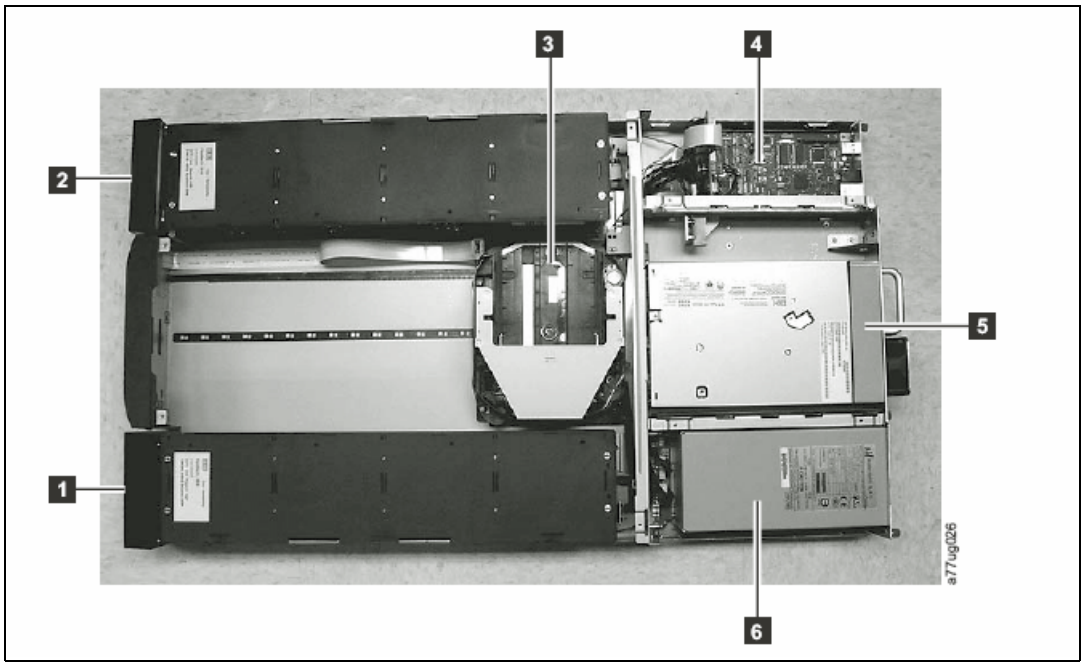


Figure 7-2 Internal top view

The numbers in Figure 7-2 highlight the following components:

1. Right cartridge magazine: This magazine can hold up to 12 cartridges.
2. Left cartridge magazine: This magazine can hold up to 12 cartridges and houses the I/O station.
3. Accessor: This component contains the library robot and the bar code reader. The accessor moves cartridges to and from the I/O station, storage slots, and tape drive.
4. Library control card: This component is a CRU and stores the user configuration information and vital product data (VPD). The RMU is embedded in this card.
5. Tape drive sled: This library supports the Ultrium 4, Ultrium 5, or Ultrium 6 tape drive. The tape drive in the library is packaged in a container called a *drive sled.* The drive sled is a CRU and is for easy removal and replacement.
6. Power supply: The power supply is a CRU. No redundant power is available.

In Figure 7-3 shows the components as they are viewed from the rear of the TS3100 tape library with a SAS Full-High tape drive.

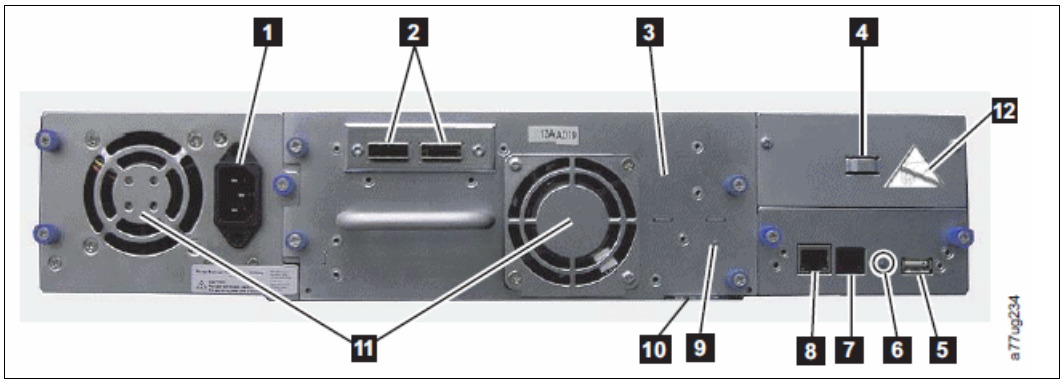


Figure 7-3 Rear panel components

The numbers in Figure 7-3 highlight the following components:

1. Power connector.
2. Host interface connectors (in this example dual port SAS).
3. Tape drive sled.
4. Shipping lock and label storage location.
5. USB port: To save library configuration information on a USB drive
6. Library Control Board (LCB) LED: When the LED is flashing (1 flash per second), it indicates normal operation.
7. Serial port (IBM Service only).
8. Ethernet port: This port is used to connect the library to a network.
9. Tape drive LED: This LED indicates the current status of the drive. When the LED is green, it indicates normal drive activity.
10. Machine type, Model number, and Serial Number pull-out label.
11. Fans.
12. Electrostatic Discharge Label.

7.2.1 Operator control panel

The library is equipped with an Operator Control Panel (OCP) on the front of the tape library. By using the OCP, simple tasks with the medium changer can be performed. With the OCP interface, the medium changer operation can be monitored, configuration changes can be made, and media access commands can be performed.

The operator control panel is shown in Figure 7-4.

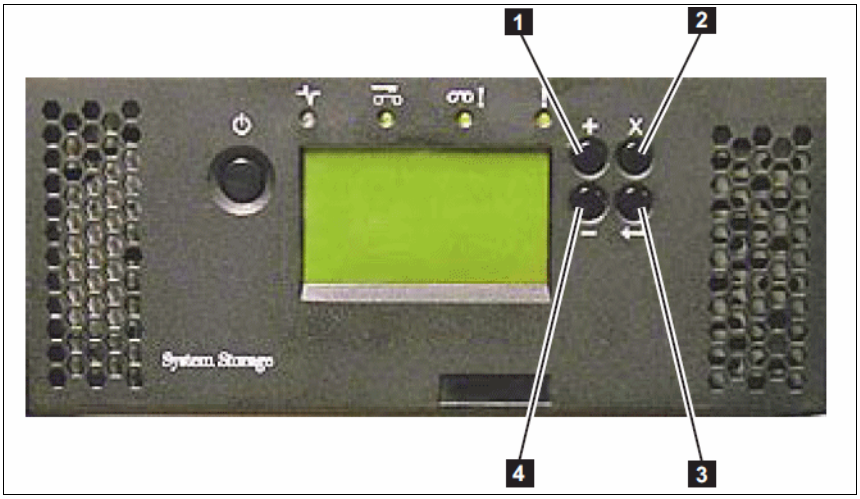


Figure 7-4 TS3100 operator control panel

Table 7-2 lists the functions of the keys on the TS3100 tape library control panel.

Table 7-2 TS3100 library control keys

Control keys	Description
1	UP (+) is the upper-left button, which is used to scroll upward through menu items.
2	CANCEL is the upper-right button, which is used to cancel a user action and return to the previous menu.
3	SELECT is the lower-right button, which is used to display a sub-menu or force an accessor action.
4	DOWN (-) is the lower-left button, which is used to scroll downward through menu items.

Figure 7-5 shows the top-level menu tree structure of the OCP.

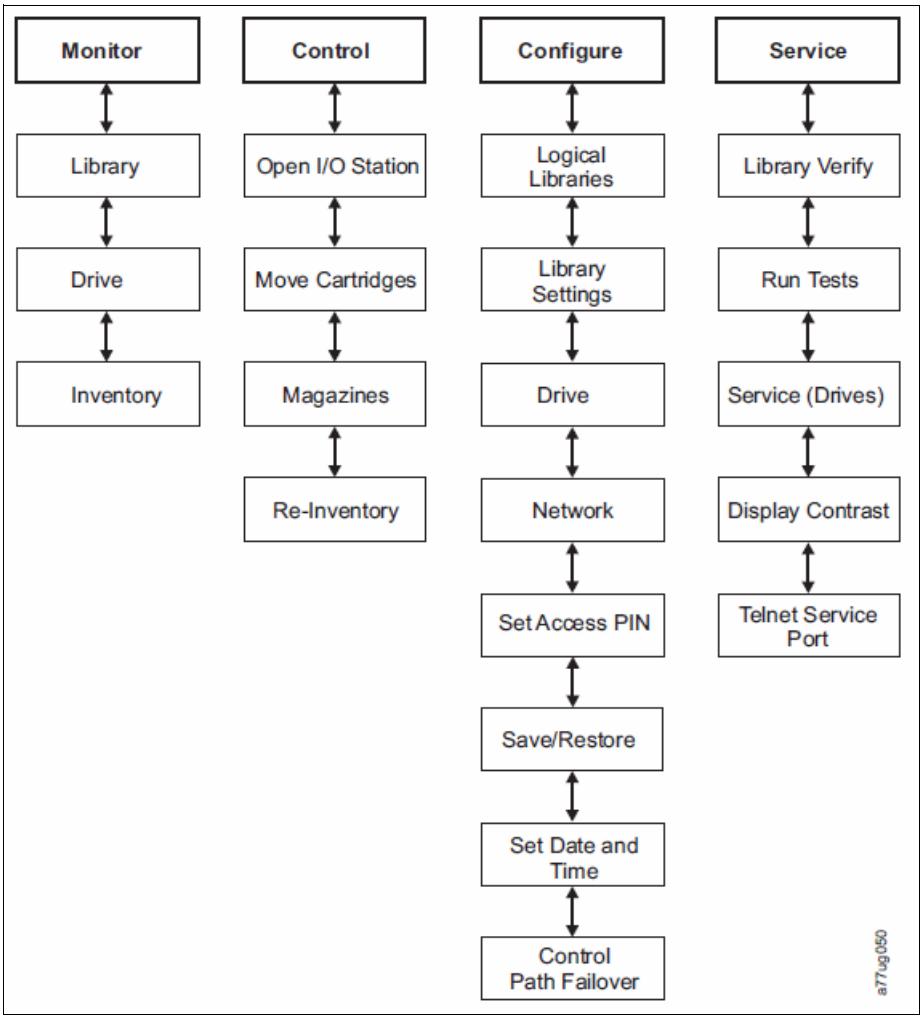


Figure 7-5 Operator control panel menu tree

For more information about all of the operator control panel functions, see the operator control panel specification in *IBM System Storage TS3100 Tape Library and TS3200 Tape Library: Setup, Operator, and Service Guide,* GA35-0545.

7.2.2 Robotics

The TS3100 tape library uses a new independent tape loader, threader motors, and a positive pin retention. These features help improve the reliability of loading and unloading a cartridge and retain the pin, even if tension is dropped. An independent loader motor coupled with the positive pin retention threads the tape with a higher level of reliability.

7.2.3 Bar code reader

The bar code reader is part of the library accessor and it does not affect the slot capacity. The bar code reader provides inventory feedback to the host application, operator panel display, and web user interface (web UI) by reading cartridge bar code labels. The library stores the customized inventory data in memory.

7.2.4 Cartridge storage

The TS3100 tape library has two removable magazines in the library. The total number of cartridge slots is 24. The right-side cartridge magazine and the left-side cartridge magazine can each hold up to 12 cartridges.

The maximum native storage capacity is 60 TB with Ultrium 6 tape drive, 36 TB with Ultrium 5 tape drive, and 19.2 TB with the IBM Ultrium 4 tape drive installed. The I/O station (or *mail slot*) is part of the left magazine. The magazines can be released by using the operator control panel or the web UI. Magazine access is password protected.

Figure 7-6 shows the right-side magazine.

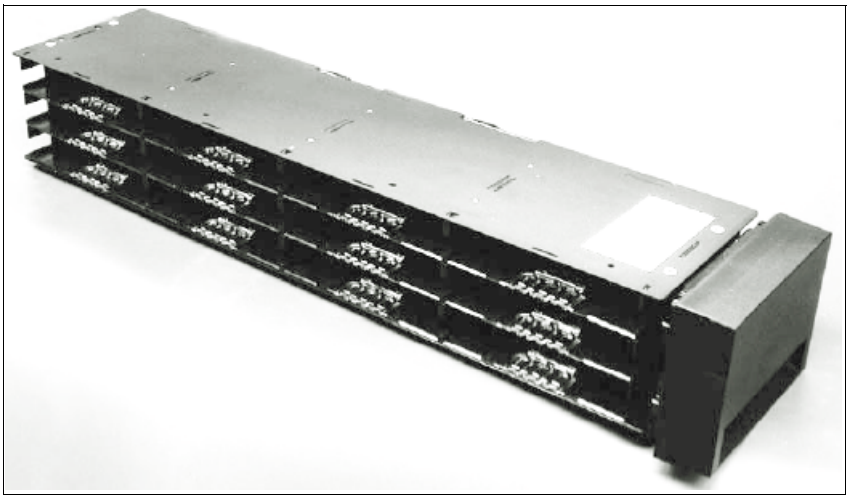


Figure 7-6 Right-side magazine

When the magazines are filled with cartridges, the web UI can be used to see which cartridges are stored in which storage slot location, as shown in Figure 7-7.

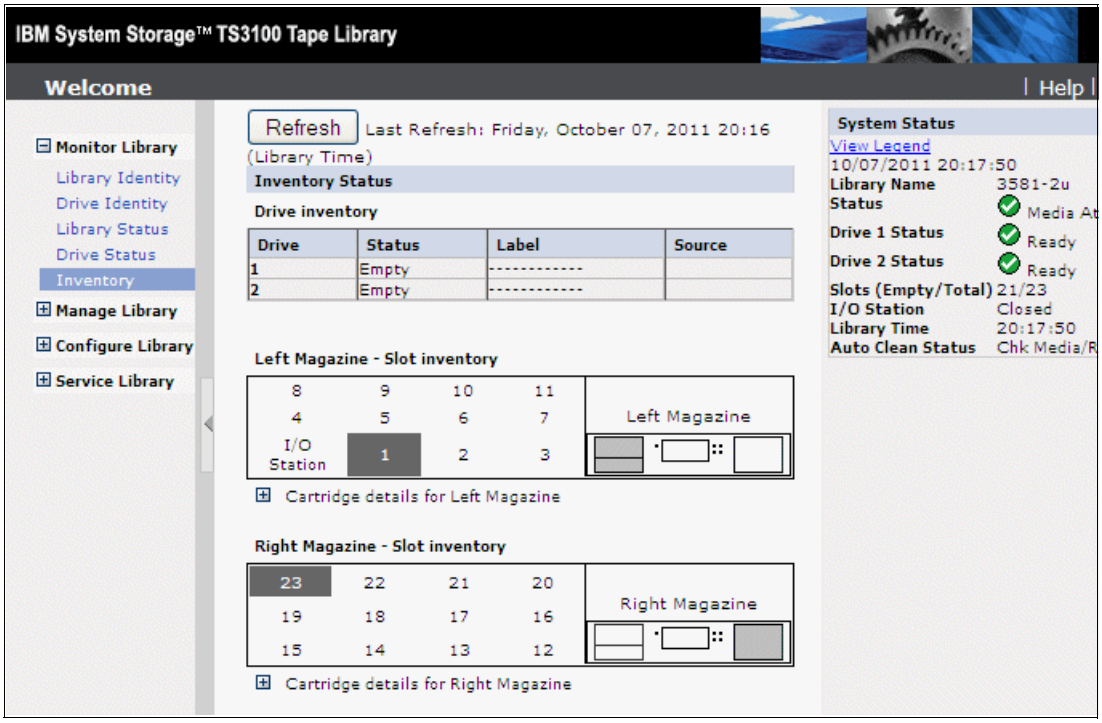


Figure 7-7 Inventory of the right magazine using the web UI

Figure 7-8 shows the left-side magazine with the I/O station on the lower left side.

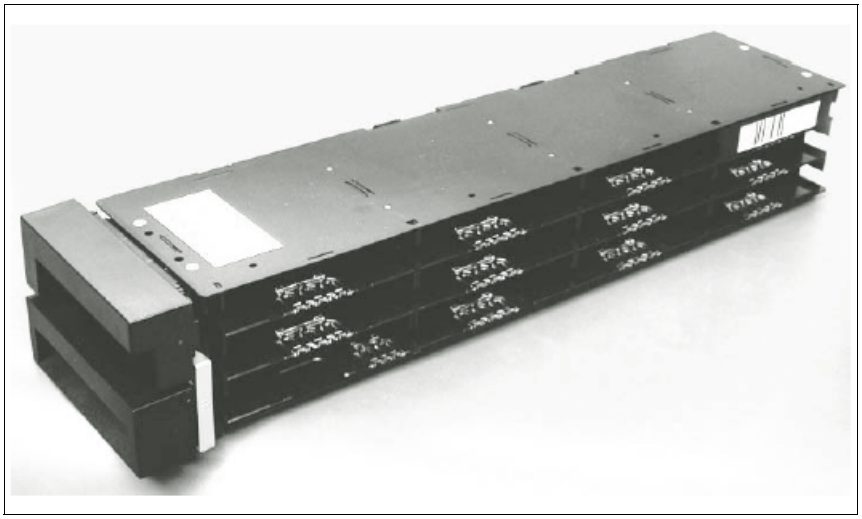


Figure 7-8 Left magazine

On some TS3100 tape libraries before Library Microcode Level 1.90, slot 11 might be labeled a “Not Used” slot that contained a “Slot Blocker,” as seen in Figure 7-8. With Library Microcode level 1.90 or higher, there is an option to remove the Slot Blocker and place that slot into use. For more information about how to remove the Slot Blocker, see *IBM System Storage TS3100 Tape Library and TS3200 Tape Library: Setup, Operator, and Service Guide*, GA35-0545.

In Figure 7-9, the left-side magazine with the I/O slot opened is shown.

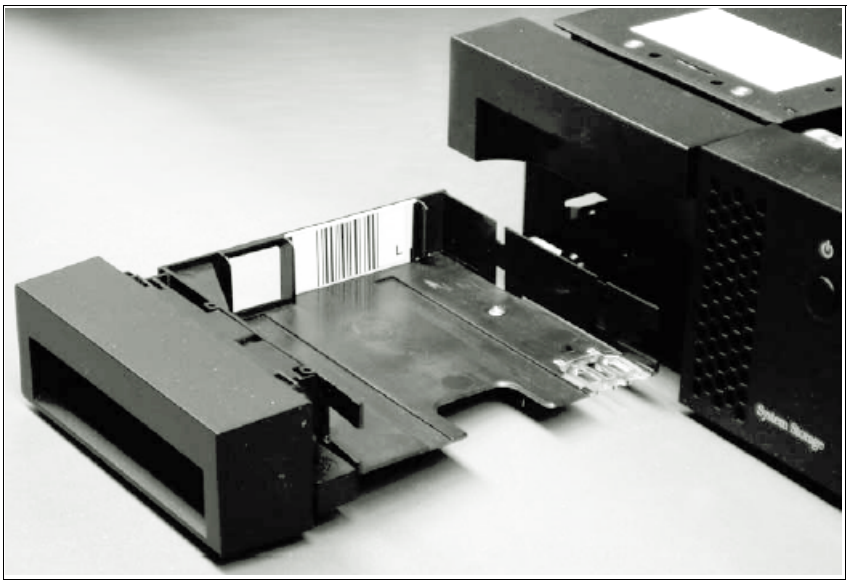


Figure 7-9 I/O station in the left magazine

7.3 IBM LTO Ultrium tape drives

This library supports Ultrium 4, Ultrium 5, and Ultrium 6 tape drives. Each tape drive in the library is packaged in a container called a *drive sled*. The drive sled is a CRU and can be quickly removed and replaced in the library. This section summarizes the characteristics of the LTO-6 Full-High and Half-High tape drives.

The Ultrium 6 Full-High tape drive supports the 8 Gbps Fibre Channel with two LC Fibre Channel connectors.

The Ultrium 6 Half-High tape drive supports the following connectors:

- 6 Gbps SAS with dual-port SFF-8088 SAS connectors
- 8 Gbps Fibre Channel with two LC Fibre Channel connectors

For more information about LTO tape drives, see Chapter 2, “Overview of IBM LTO Ultrium tape drives” on page 41.

7.3.1 Ultrium 6 tape drives

The IBM LTO Ultrium 6 tape drive is the sixth-generation LTO Ultrium tape drive in the IBM LTO Ultrium family of products. The Ultrium 6 tape drive in the TS3100 tape library offers significant improvements over the Ultrium 5 tape drive. Similar to the LTO-5, the IBM Ultrium 6 tape drive contains the electronics and logic for reading and writing data, controlling the tape drive, managing the data buffer, and handling error recovery procedures. The LTO-6 tape drive is designed as a CRU and the drive can by easily replaced, if necessary.

Cartridge compatibility

The Ultrium 6 drive uses the IBM LTO Ultrium 2.5 TB Data Cartridge and is compatible with the cartridges of its predecessors, the IBM Ultrium tape drive Generation 5 and Generation 4. The drive performs the following functions:

- Reads and writes Ultrium 6 cartridges in Ultrium 6 format, including WORM and data encryption.
- Reads and writes Ultrium 5 cartridges in Ultrium 5 format, including WORM and data encryption.
- Reads but does not write Ultrium 4 cartridges, including WORM.
- Does not read or write Ultrium 3, Ultrium 2, and Ultrium 1 cartridges.

The drive reads tapes that were written by other licensed Ultrium 4, Ultrium 5, and Ultrium 6 tape drives, and writes to tapes that can be read by other licensed Ultrium 5 and Ultrium 6 tape drives. In addition to using the IBM LTO Ultrium Data Cartridge with up to 2.5 TB capacity, the drive offers read and write capability for all certified LTO Ultrium tape cartridges.

Platform support

The value of the TS3100 tape library can be increased by managing it with tape management solutions, such as IBM Tivoli Storage Manager or other third-party storage software. The following platforms support the TS3100 tape library:

- IBM platforms:
  - Selected IBM Power Systems Models:
    - AIX V5.3 TL7 and above
    - i 6.1.1-7.1
  - Flex Systems (LTO-6)
  - System p
  - System i
  - System x
  - System z Linux
  - Supported Microsoft and Linux platforms
- Other vendors:
  - Oracle: Solaris 10 and 11
  - Hewlett Packard: HP-UX 11iV3
  - Microsoft Corporation:
    - Microsoft Windows Server 2008
    - Microsoft Windows Server 2012
  - Linux:
    - Red Hat Advanced Server Enterprise Linux 4.6-6.1
    - SUSE Enterprise Server 10 and 11

Performance highlights

If applications that are highly dependent on tape-processing speed are used, the significant performance improvements that are provided by this tape drive can be realized. Table 7-3 shows the performance of the LTO-6 tape drive.

Table 7-3 Performance characteristics

Performance characteristics	Ultrium 6 tape drive
Native data rate	160 MBps (with Ultrium 6 media)
Maximum Interface Transfer Rate (maximum sustained with maximally compressible data)	550 MBps (SAS) 745 MBps (FC)
Interface Burst transfer rate	600 MBps (SAS) 800 MBps (FC)
Nominal load-to-ready time	12 seconds
Nominal unload time	17 seconds (FH) 22 seconds (HH)
Average rewind time	42 seconds (FH) 62 seconds (HH)

By using the built-in data-compression capability of the tape drive, greater data rates than the native data transfer rate can be achieved. However, the actual throughput is a function of many components, such as the host system processor, disk data rate, block size, data compression ratio, SCSI bus capabilities, and system or application software.

For more information about LTO-6 tape drives, see “IBM LTO Ultrium 6 Half-High library drives” on page 85.

7.3.2 Path failover

The TS3100 supports Path Failover feature. Path Failover is a combination of two previous features: Control Path Failover and Data Path Failover.

The device driver Path Failover support configures multiple physical control paths to the same logical library within the device driver and provides automatic failover to an alternate control path when a permanent error occurs on one path. This function is not apparent to the running application.

7.3.3 Encryption

The IBM TS3100 tape library supports data encryption with LTO 6 tape drives. The following modes of encryption are supported:

- System Managed (available for AIX, Linux, Solaris, and Windows)
- Library Managed (available for OS/400, i5/OS, AIX, Linux, HP-UX, Solaris, and Windows)
- Application Managed (IBM Tivoli Storage Manager)

For LTO Ultrium 6, the Transparent LTO encryption feature is required for enabling encryption. The IBM Security Key Lifecycle Manager is required for enabling System Managed and Library Managed encryption.

The installation of an Ultrium 6 tape drive with encryption might require code updates for IBM Power Systems, and supported open systems devices drivers or storage management software. An update of the open systems device drivers can be obtained from the Fix Central download portal at this website:

http://www.ibm.com/support/fixcentral

For more information about Encryption, see 2.2, “Tape encryption overview” on page 67.

7.3.4 Linear Tape File System

The TS3100 support IBM Linear Tape File System (LTFS) Library Edition and IBM LTFS Storage Manager software.

LTFS provides a software to manage, monitor, archive, and restore files. LTFS is the first file system that works with the multiple partitioning that is available on LTO Ultrium 6 and LTO Ultrium 5 tapes drives and brings a new level of use and portability to open systems tape storage.

This storage software helps to reduce complexity in data management and access time through the enablement of a self-describing tape that includes a simple file index. LTFS allows files and directories to be shown on the desktop, directory listing, and to drag-and-drop file to and from tape. It also supports data exchange and has a simple one-time installation.

IBM LTFS LE allows the TS3100 tape library to be mounted and viewed as a single file system with the individual tape cartridge viewed as subdirectories within the file system. It is the perfect solution for those in the Media and Entertainment industry and other fields that need massive data storage on tape for on retention periods, such as banking, scientific research, and government sectors.

IBM LTFS Storage Manager Edition provides storage lifecycle management of (multimedia) files and resource management that use IBM LTFS LE, which reduces digital content archive software licensing and video tape cartridge costs. LTFS Storage Manager provides a tool that can use metadata to arrange, search, and manage files at the user’s convenience according to the policies they decide.

For more information about LTFS LE, see this website:

http://www.ibm.com/tape/ltfs

For more information about LTFS, see *IBM Linear Tape File System Installation and Configuration*, SG24-8090.

7.3.5 Notifications

The TS3100 has the following options available for sending notifications to the host:

- Simple Mail Transfer Protocol

  Simple Mail Transfer Protocol (SMTP) automatically sends an email that contains event information to the email addresses that are specified whenever an event of a certain level occurs.

- Simple Network Management Protocol

  Simple Network Management Protocol (SNMP) is a set of protocols that is used for managing complex networks. SNMP works by sending messages called *protocol data units* (PDUs) to various parts of a network. Agents, which are SNMP-compliant devices, store data about themselves in Management Information Bases (MIBs) and return this data to the SNMP requesters, such as the host's monitoring application.

7.4 Physical attachments

The TS3100 tape library with Ultrium 6 tape drives are available with the following interfaces:

- Native Fibre Channel 8 Gbps
- SAS 6 Gbps

Designed for tape automation, the TS3100 tape library can be attached to the following servers:

- IBM BladeCenter
- IBM Power Systems
- IBM System p
- IBM System i
- IBM System x
- IBM System z
- Advanced Micro Devices (AMD)
- Hewlett Packard
- Intel (x86 and x86_64)
- Oracle

For more information about the latest supported servers, see this website:

http://www.ibm.com/systems/support/storage/config/ssic/

7.4.1 Fibre Channel interface

Ultrium 6 Fibre Channel tape drives use LC duplex fibre optic cables. The maximum distances that a library supports on a Fibre Channel link are determined by the link speed, the type of fibre (50-micron or 62.5-micron), and the device to which the library is attached.

Figure 7-10 shows the rear of the FC Half-High tape drive.

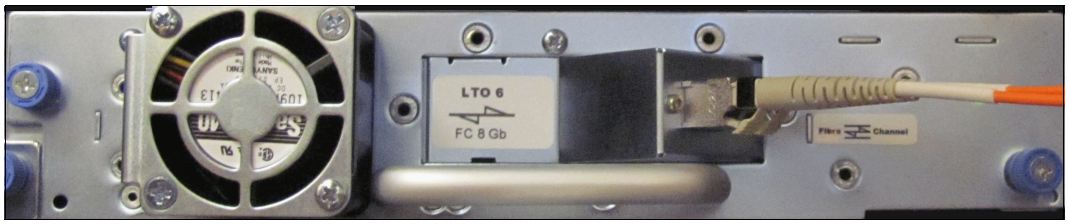


Figure 7-10 Rear of the FC Half-High tape drive

Figure 7-11 shows the rear of the FC Full-High tape drive.

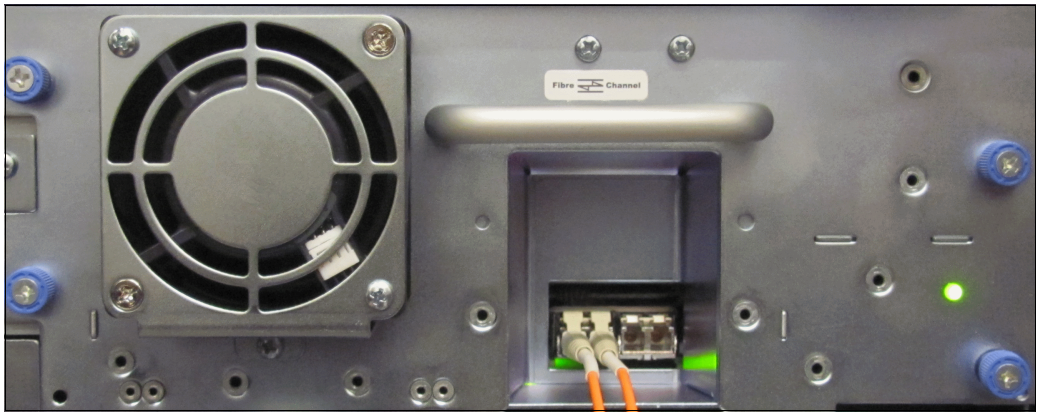


Figure 7-11 Rear of the FC Full-High tape drive

For more information about Fibre Channel interface, see “Fibre Channel” on page 63.

HBA support

Make sure that the FC HBA of your server is supported. Check the IBM HBA support in the System Storage Interoperability Center (SSIC) at this website:

`http://www.ibm.com/systems/support/storage/ssic/interoperability.wss`

Tip: When Fibre tape drives are connected to a Fibre HBA on the host server, make sure the Fibre Channel Tape Support option is enabled on the Fibre HBA so that proper class 3 error recovery is performed on the Fibre Channel. For more information about this option, see the HBA manufacturer.

7.4.2 SAS interface

The IBM Ultrium 6 Half-High tape drives come with two Mini-SAS (SFF-8088) interfaces on the back of the drive. For more information about SAS, see “Serial-attached SCSI history” on page 59.

Figure 7-12 on page 219 shows the rear of the SAS Half-High tape drive with two SFF-8088 interfaces.

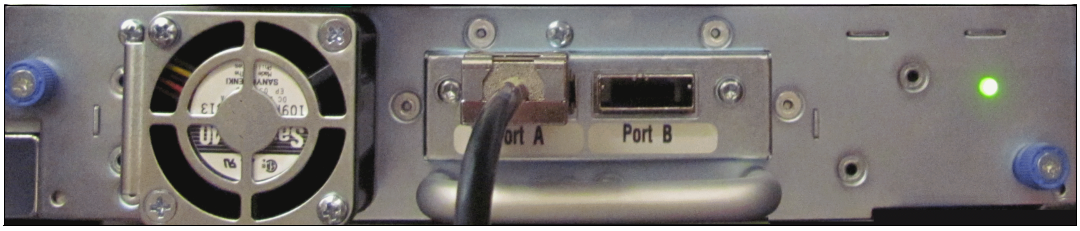


Figure 7-12 Rear of the SAS Half-High tape drive

HBA support

Verify that the HBA of your server is supported. Check the IBM interoperability matrix at the System Storage Interoperation Center (SSIC) page at this website:

`http://www.ibm.com/systems/support/storage/ssic/interoperability.wss`

7.5 Media

To ensure that the IBM Ultrium tape drive conforms to the specifications of IBM for reliability, only IBM LTO Ultrium tape cartridges should be used. Other LTO-certified data cartridges can be used, but they might not meet the standards of reliability that are established by IBM.

7.5.1 Data cartridges

All sixth generations contain ½-inch, dual-coated, metal-particle tape. Table 7-4 lists the native data capacity of Ultrium data cartridges.

Table 7-4 Ultrium native capacity

Data cartridge	Native data capacity
Ultrium 6 and Ultrium 6 WORM	2.5 TB (6.25 TB at a 2.5:1 compression ratio)
Ultrium 5 and Ultrium 5 WORM	1.5 TB (3.0 TB at a 2:1 compression ratio)
Ultrium 4 and Ultrium 4 WORM	800 GB (1.6 TB at a 2:1 compression ratio)
Ultrium 3 and Ultrium 3 WORM	400 GB (800 GB at a 2:1 compression ratio)
Ultrium 2	200 GB (400 GB at a 2:1 compression ratio)
Ultrium 1	100 GB (200 GB at a 2:1 compression ratio)

Table 7-5 shows the compatibility among the six types of Ultrium cartridges.

Table 7-5 Ultrium data cartridge compatibility

IBM Ultrium tape drive	IBM TotalStorage LTO Ultrium Data Cartridge					
	2.5 TB (Ultrium 6)	**1.5 TB (Ultrium 5)**	**800 GB (Ultrium 4)**	**400 GB (Ultrium 3)**	**200 GB (Ultrium 2)**	**100 GB (Ultrium 1)**
Ultrium 6	Read/Write	Read/Write	Read only			
Ultrium 5		Read/Write	Read/Write	Read only		
Ultrium 4			Read/Write	Read/Write	Read only	
Ultrium 3				Read/Write	Read/Write	Read only
Ultrium 2					Read/Write	Read/Write
Ultrium 1						Read/Write

For more information about tape cartridges, see 2.1.4, “Tape cartridge” on page 48.

Write Once Read Many

Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a WORM feature is available on IBM LTO Ultrium generation 3, 4, 5, and 6 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and by using a special WORM tape cartridge.

A specially formatted WORM tape cartridge is required because standard Read/Write media are incompatible with the WORM feature. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique Cartridge Memory (CM) chip serial number and the unique tape media serial number.

For more information about WORM media, see “WORM tape format” on page 47.

7.5.2 Cleaning cartridges

A specially labeled IBM LTO Universal Ultrium Cleaning Cartridge cleans the drive in the library.

The drive determines when a head needs cleaning and communicates this information to the library. When the cleaning is finished, the drive ejects the cartridge, and the picker takes the cartridge and places it back in any storage slot. A cleaning cartridge can be removed by exporting it from the library.

The IBM Cleaning Cartridge is valid for 50 uses. The LTO-CM chip of the cartridge tracks the number of times that the cartridge is used.

For more information about Cleaning Cartridges, see “Specifications for cleaning cartridges” on page 55.

7.5.3 Cartridge memory chip

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip. This chip contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), and statistical information about use of the cartridge.

The LTO-CM also helps to determine the reliability of the cartridge by storing data about its age, the number of times it was loaded, and the number of errors it has accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the Ultrium 6 Tape Cartridge Memory Chip is 16320 bytes.

For more information about the LTO-CM, see “Cartridge memory” on page 52.

7.6 Specifications

The TS3100 tape library is a medium-sized tape library. The dimensions are described next.

7.6.1 Physical specifications

Table 7-6 lists the physical specifications for the library.

Table 7-6 Physical specifications

Specification	Measurement
Height	Rack mount 87.6 mm (3.44 in), Stand-alone 97.6 mm (3.84 in)
Width	447.5 mm (17.6 in.)
Depth	Rack mount 740 mm (29.13 in), Stand-alone 810 mm (31.9 in)
Weight with 1 drive and without media	15.59 kg (34.37 lbs.)
Weight with media	20.67 kg (45.57 lbs.)
Specification	2U library

7.6.2 Power specifications

Table 7-7 lists the power specifications for the library.

Table 7-7 Power specifications

Specification	Measurement
AC power voltage	100-127 VAC; 200-240 VAC (4 - 2 A)
Line frequency	50-60 Hz

7.7 Feature codes

The TS3100 tape library can be ordered with the optional features that are listed in Table 7-8. For more information, see this website:

http://www.ibm.com/systems/storage/tape/ts3100/index.html

Table 7-8 Optional features

Feature code	Description
1682	Path Failover (automatic data path and control path failover)
5400	SAS/Mini-SAS 4X Interposer
5402	2.0M SAS/Mini-SAS 1x Cable
5500	Mini-SAS/Mini-SAS 4X Interposer
5502	2.0M Mini-SAS/Mini-SAS 1x Cable
5604	4.5 m (14.8 ft.) VHDCI/HD68 SCSI Cable
5610	10 m (32 ft.) VHDCI/HD68 SCSI Cable
5900	Transparent LTO Encryption. Provides license keys to enable SME and LME
6013	13 m LC-LC Fibre Channel Cable
6025	25 m LC-LC Fibre Channel Cable
7002	Rack Mount Kit with Power Cord
7703	OEM - No IBM Logo
8002	Universal Cleaning Cartridge
8106	Right-side magazine set
8109	Left-side 2U magazine
8143	Ultrium 4 Full-High LVD SCSI tape drive
8144	Ultrium 4 Full-High Fibre Channel tape drive
8145	Ultrium 4 Full-High SAS tape drive
8148	Ultrium 4 Half-High Fibre Channel tape drive Version 2
8149	Ultrium 4 Half-High SAS tape drive Version 2
8244	Ultrium 5 Full-High Fibre Channel tape drive
8245	Ultrium 5 Full-High SAS tape drive
8247	Ultrium 5 Half-High SAS tape drive
8248	Ultrium 5 Half-High Fibre tape drive
8344	Ultrium 6 Fibre Channel Drive
8347	Ultrium 6 Half-High SAS Drive
8348	Ultrium 6 Half-High Fibre Channel Drive
8405	Data Cartridge (Generation 4) 5-packs
8505	Data Cartridge (Generation 5) 5-packs

Feature code	Description
8605	Data Cartridge (Generation 6) 5-packs
9001	Driveless Library Unit
9210	Attached to HP-UX System
9211	Attached to Oracle Solaris System
9212	Attached to Windows System
9215	Attached to Linux System
9400	Attached to i5/OS or IBM OS/400 System
9600	Attached to AIX System
9800-9847	Power cord (different feature code for each country)
9848	Additional Rack to Power Distribution Unit (PDU) Line Cord

8

IBM TS3200 tape library

The IBM TS3200 tape library (Machine Type 3573, Model L4U) is a mid-level desktop or a rack-mounted unit that incorporates up to four tape drives that can operate in random or sequential mode. The robotics inside the library move the cartridges to and from the tape drive, which permits unattended backup. Four removable magazines can store a total of 48 cartridges. A dedicated three-slot I/O station is available for importing and exporting cartridges.

The IBM TS3200 tape library incorporates the IBM Linear Tape-Open (LTO) Half-High and Full-High 6 Gbps serial-attached SCSI (SAS) and 8 Gbps Fibre Channel (FC) drives. Mixed Ultrium generations and attachment tape drive types are supported where drive space is available.

The following tape drives are available for the IBM TS3200 tape library:

- Ultrium 6 Full-High 8 Gbps FC
- Ultrium 6 Half-High 6 Gbps SAS
- Ultrium 6 Half-High 8 Gbps FC
- Ultrium 5 Full-High 6 Gbps SAS
- Ultrium 5 Full-High 8 Gbps FC
- Ultrium 5 Half-High 6 Gbps SAS
- Ultrium 5 Half-High 8 Gbps FC
- Ultrium 4 Full-High 3 Gbps SAS
- Ultrium 4 Full-High 4 Gbps FC
- Ultrium 4 Half-High 6 Gbps SAS (V2)
- Ultrium 4 Half-High 8 Gbps FC (V2)
- Ultrium 4 Full-High Low Voltage Differential (LVD) SCSI

Up to four Half-High IBM Ultrium 4, Ultrium 5, and Ultrium 6 tape drives or two Full-High IBM Ultrium 4, Ultrium 5, and Ultrium 6 tape drives can be installed in the TS3200 tape library.

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Tape encryption is supported on the IBM Ultrium LTO-4, LTO-5, and LTO-6 tape drive with the SAS and Fibre Channel interface. The IBM TS3200 tape library supports application-managed encryption (AME), system-managed encryption (SME), and library-managed encryption (LME).

The tape library has four indicator LEDs and one LCD on the front. The LEDs can be used to indicate ready/activity, use cleaning tape, media attention, and error.

Standard features are a bar code reader and a Remote Management Unit (RMU). In this chapter, the terms *RMU* and *web user interface* are used interchangeably.

This chapter includes the following sections:

- Product description
- TS3200 tape library components
- IBM LTO Ultrium tape drives
- Physical attachments
- Media
- Specifications
- Feature codes

For the remainder of this chapter, we use the terms TS3200 or TS3200 tape library as abbreviations for the IBM TS3200 tape library.

8.1 Product description

The IBM TS3200 tape library (Machine Type 3573, Model L4U) supports two LTO-4, LTO-5, or LTO-6 Full-High tape drives or four LTO-4, LTO-5, or LTO-6 Half-High tape drives.

Figure 8-1 shows the front view of the TS3200 tape library. The left and right sections hold the cartridge magazines. The I/O slot is accessible on the lower left side.



Figure 8-1 IBM TS3200 tape library

The IBM Ultrium 4, Ultrium 5, and Ultrium 6 LTO tape drive with an FC or a SAS interface are encryption-capable. The TS3200 tape library supported encryption methods are AME, SME, and LME.

Depending on the IBM Ultrium tape drive that is installed in the TS3200 tape library, the following data cartridges can be used:

- The TS3200 tape library uses the IBM TotalStorage LTO Ultrium 2.5 TB Data Cartridge or 2.5 TB Write Once Read Many (WORM) Cartridge when the IBM Ultrium 6 tape drive is installed. The Ultrium 6 tape drive has the capability of writing up to 2.5 TB native capacity and up to 6.25 TB with 2.5:1 compression ratio. IBM Ultrium 6 tape drives can read and write LTO Ultrium 5 Data Cartridges, can read Ultrium 4 Data Cartridges, and do not support Ultrium 3, Ultrium 2, and Ultrium 1 Data Cartridges.
- The TS3200 tape library uses the IBM TotalStorage LTO Ultrium 1.5 TB Data Cartridge or 1.5 TB Write Once Read Many (WORM) Cartridge when the IBM Ultrium 5 tape drive is installed. The Ultrium 5 tape drive has the capability of writing up to 1.5 TB native capacity and up to 3.0 TB with a 2:1 compression ratio. IBM Ultrium 5 tape drives can read and write LTO Ultrium 4 Data Cartridges, can read Ultrium 3 Data Cartridges, and do not support Ultrium 1 and Ultrium 2 Data Cartridges
- The TS3200 tape library uses the IBM TotalStorage LTO Ultrium 800 GB Data Cartridge or 800 GB WORM Cartridge when the IBM Ultrium 4 tape drive is installed. The Ultrium 4 tape drive has the capability of writing up to 800 GB native capacity and up to 1.6 TB with a 2:1 compression ratio. IBM Ultrium 4 tape drives can read and write LTO Ultrium 3 Data Cartridges, can read Ultrium 2 Data Cartridges, and do not support Ultrium 1 Data Cartridges.

The library capacity is 48 tape cartridges, which provides a media capacity of up to 120 TB (300 TB with a 2.5:1 compression ratio) data storage per TS3200 tape library with LTO Ultrium 6 tape drives. Table 8-1 shows the library storage capacity and data transfer rate.

Table 8-1 Library storage capacity and data transfer rate

Characteristics	4U library specification
Maximum storage capacity: Ultrium 6 Data Cartridges	► 48 data cartridges ► Native: 120 TB ► Compressed: 300 TB
Maximum storage capacity: Ultrium 5 Data Cartridges	► 48 data cartridges ► Native: 72 TB ► Compressed: 144 TB (a 2:1 compression ratio)
Maximum storage capacity: Ultrium 4 Data Cartridges	► 48 data cartridges ► Native: 38.4 TB ► Compressed: 75.2 TB (a 2:1 compression ratio)
Maximum burst data transfer rate	► SAS: 600 MBps ► Fibre Channel: 800 MBps

Depending on the way that the TS3200 tape library is ordered, you specify the required number of tape drives and drive types by using feature codes.

8.1.1 TS3200 tape library Ultrium 6 models

The following models are available for the TS3200 tape library:

- The 3573-L4U FC8344 specifies an IBM Ultrium 6 Full-High Fibre Channel tape drive. The Ultrium 6 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 6 tape drive has a native data transfer rate of 160 MBps.
- The 3573-L4U FC8347 specifies an IBM Ultrium 6 Half-High tape drive that has a SAS interface and a native data transfer rate of up to 6 Gbps. The SAS Ultrium 6 tape drive comes with dual-port Mini-SAS (SFF-8088) interfaces. The Ultrium 6 tape drive provides a sustained native data transfer rate of 160 MBps.
- The 3573-L4U FC8348 specifies an IBM Ultrium 6 Half-High Fibre Channel tape drive. The Ultrium 6 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 6 tape drive has a native data transfer rate of 160 MBps.

8.1.2 TS3100 tape library Ultrium 5 models

The following models are available for the TS3100 tape library:

- The 3573-L4U FC8244 specifies an IBM Ultrium 5 Full-High Fibre Channel tape drive. The Ultrium 5 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 5 tape drive has a native data transfer rate of 140 MBps.
- The 3573-L4U FC8245 specifies an IBM Ultrium 5 Full-High tape drive that has a SAS interface and a native data transfer rate of up to 6 Gbps. The SAS Ultrium 5 tape drive comes with dual-port Mini-SAS (SFF-8088) interfaces. The Ultrium 5 tape drive provides a sustained native data transfer rate of 140 MBps.

- The 3573-L4U FC8247 specifies an IBM Ultrium 5 Half-High tape drive that has a SAS interface and a native data transfer rate of up to 6 Gbps. The SAS Ultrium 5 tape drive comes with dual-port SFF-8088 interfaces. The Ultrium 5 tape drive provides a sustained native data transfer rate of 140 MBps.
- The 3573-L4U FC8248 specifies an IBM Ultrium 5 Half-High Fibre Channel tape drive. The Ultrium 5 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 5 tape drive has a native data transfer rate of 140 MBps.

8.1.3 TS3200 tape library Ultrium 4 models

The following models are available for the TS3200 tape library:

- The 3573-L4U FC8143 specifies an IBM Ultrium 4 Full-High LVD SCSI tape drive. The Ultrium 4 LVD SCSI drive has an LVD Ultra 160 SCSI that can be connected to LVD Fast Wide adapters. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.
- The 3573-L4U FC8144 specifies an IBM Ultrium 4 Full-High tape drive with a 4 Gbps Fibre Channel interface. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.
- The 3573-L4U FC8145 specifies an IBM Ultrium 4 Full-High tape drive that has a SAS interface, which has a native data transfer rate of up to 3 Gbps. The SAS Ultrium 4 tape drive comes with an SFF-8088 interface. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.
- The 3573-L4U FC8148 specifies an IBM Ultrium 4 Half-High tape drive (V2). The Ultrium 4 Fibre Channel drive has an 8 Gbps Fibre Channel interface that can be connected to Fibre Channel host adapters. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.
- The 3573-L4U FC8149 specifies an IBM Ultrium 4 Half-High tape drive (V2) that has a SAS interface, which has a native data transfer rate of up to 6 Gbps. The SAS Ultrium 4 tape drive comes with dual-port SFF-8088 interfaces. The Ultrium 4 tape drive provides a sustained native data transfer rate of 120 MBps.

8.2 TS3200 tape library components

The TS3200 tape library has an improved robotic system that moves along an axis from front to back between the cartridge magazines. This limited movement provides robust robotics. The standard bar code reader is installed on the accessor.

Figure 8-2 shows the top view of the TS3200 tape library.

Important: Figure 8-2 is for reference only. The customer is not authorized to remove the top cover of the library. No customer-serviceable components are inside the library. All customer-replaceable units (CRU) can be removed via the rear panel of the library.

The right side is the rear of the library, and the left side is the front of the library. The TS3200 tape library is a modular system, so that the client can change parts easily.

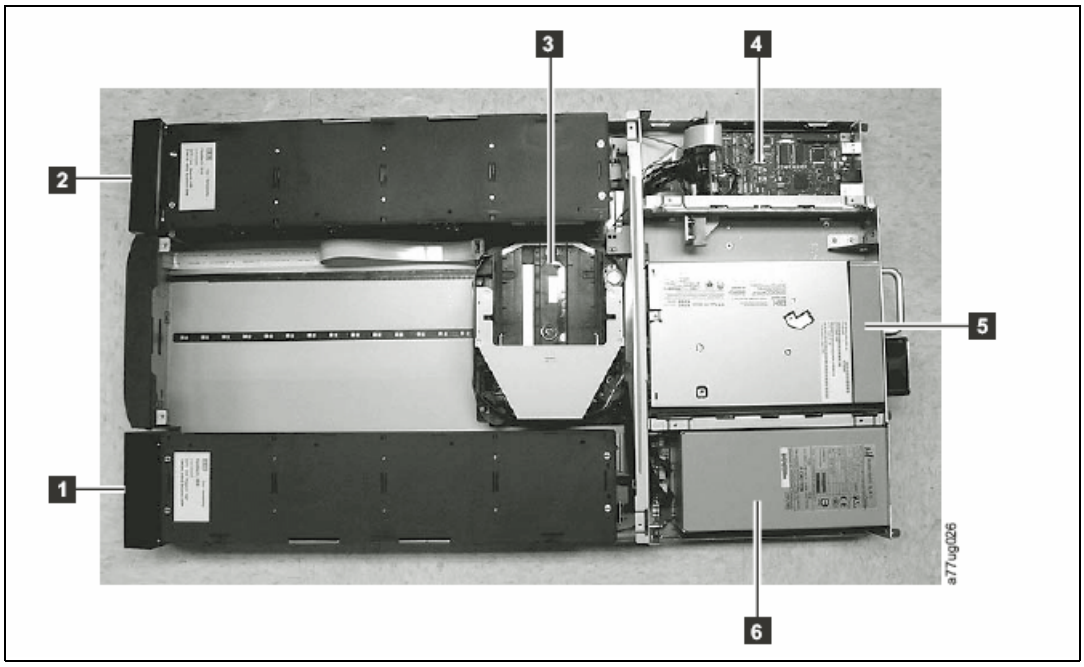


Figure 8-2 Internal top view

The numbers in Figure 8-2 highlight the following components:

1. Right cartridge magazines: These two magazines can hold up to 24 cartridges.
2. Left cartridge magazines: These two magazines can hold up to 24 cartridges and house the 3 slot I/O station.
3. Accessor: This component contains the library robot and the bar code reader. The accessor moves cartridges to and from the I/O station, storage slots, and tape drive.
4. Library control card: This component is a customer-replaceable unit (CRU) and stores the user configuration information and vital product data (VPD). The RMU is embedded in this card.
5. Tape drive sled: This library supports the Ultrium 3, Ultrium 4, Ultrium 5, or Ultrium 6 tape drive. The tape drive in the library is packaged in a container called a *drive sled*. The drive sled is a CRU and is for easy removal and replacement.
6. Power supply: The power supply is a CRU. No redundant power is available.

In Figure 8-3 shows the components as they are viewed from the rear of the TS3200 tape library with a Fibre Full-High tape drive, Half-High SCSI tape drive, and a Half-High SAS tape drive.

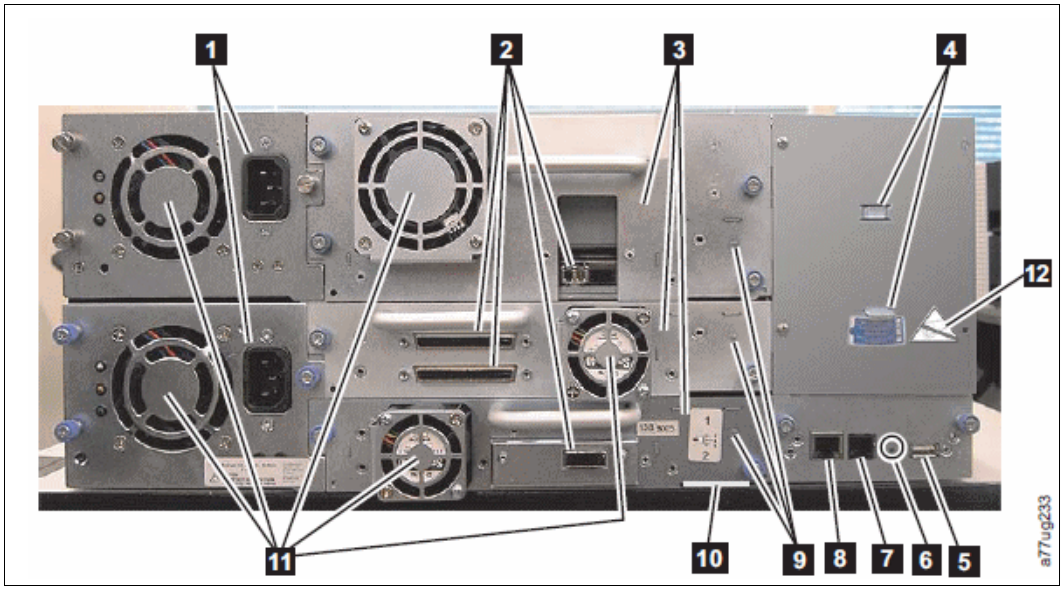


Figure 8-3 Rear panel components

The numbers in Figure 8-3 highlight the following components:

1. Power connector.
2. Host interface connectors (in this example single-port SAS, FC and SCSI).
3. Tape drive sled.
4. Shipping lock and label storage location.
5. USB port, which is used to save library configuration information on a USB drive.
6. Library Control Board (LCB) LED: if the LED is flashing (1 flash per second) this indicates normal operation.
7. Serial port (IBM Service only).
8. Ethernet port, which is used to connect the library to a network.
9. Tape drive LED: this LED indicates the current status of the drive. When the LED is green, it indicates normal drive activity.
10. Machine type, Model number, and Serial Number pull-out label.
11. Fans.
12. Electrostatic Discharge Label.

8.2.1 Operator Control Panel

The library is equipped with an Operator Control Panel (OCP) on the front of the tape library. By using the OCP, simple tasks that involve the medium changer can be performed. With the OCP interface, the medium changer operation can be monitored, configuration changes can be made, and media access commands can be performed.

The operator control panel is shown in Figure 8-4.

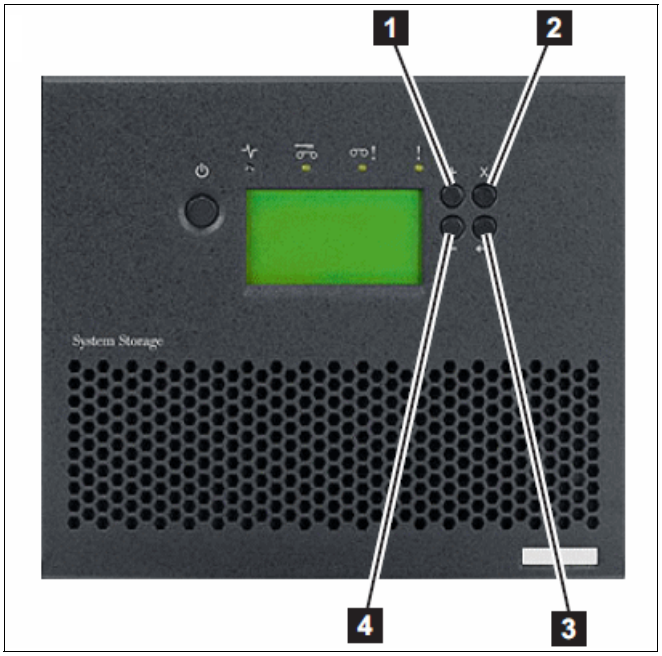


Figure 8-4 TS3200 operator control panel

Table 8-2 lists the functions of the keys on the TS3200 tape library control panel.

Table 8-2 TS3200 tape library control keys

Control keys	Description
1	UP (+) is the upper-left button, which is used to scroll upward through menu items.
2	CANCEL is the upper-right button, which is used to cancel a user action and return to the previous menu.
3	SELECT is the lower-right button, which is used to display a sub-menu or force an accessor action.
4	DOWN (-) is the lower-left button, which is used to scroll downward through menu items.

Figure 8-5 shows the top-level menu tree structure of the OCP.

For more information about all of the operator control panel functions, see the operator control panel specification in *IBM System Storage TS3100 Tape Library and TS3200 Tape Library: Setup, Operator, and Service Guide,* GA35-0545.

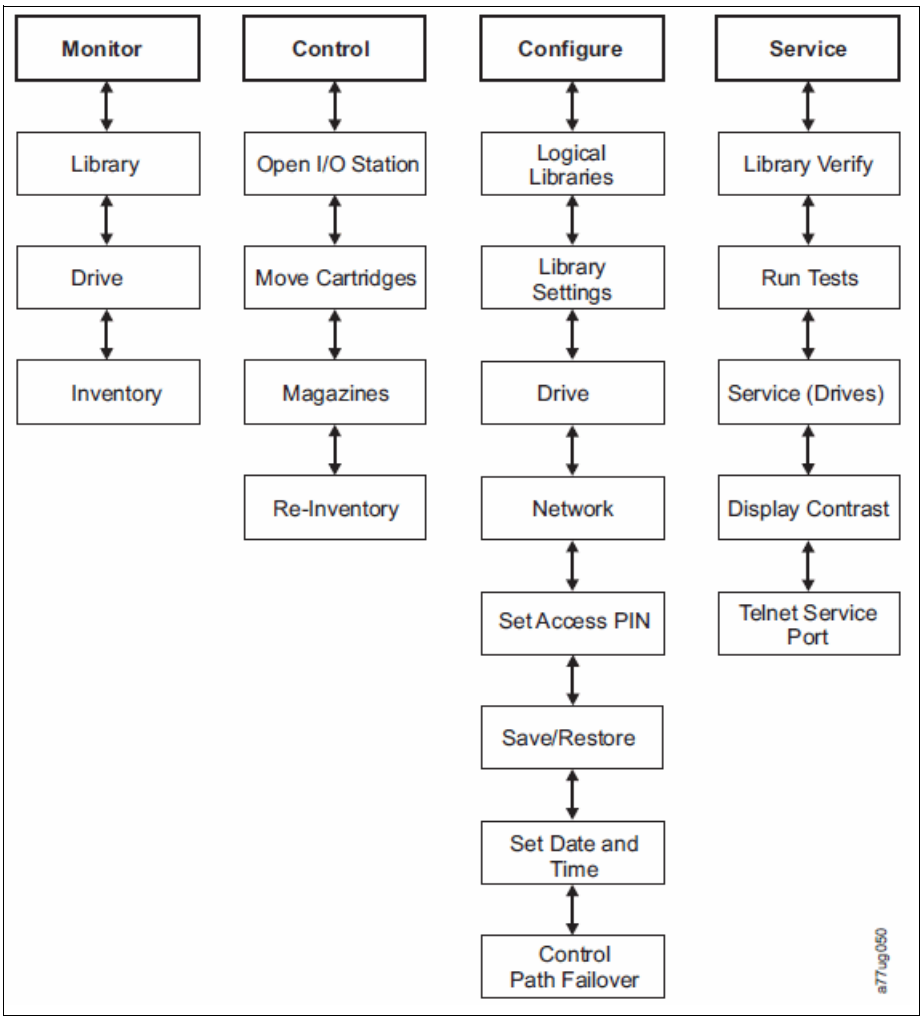


Figure 8-5 Operator control panel menu tree

8.2.2 Robotics

The TS3200 tape library uses a new independent tape loader, threader motors, and a positive pin retention. These features help improve the reliability of loading and unloading a cartridge and retain the pin, even if tension is dropped. An independent loader motor coupled with the positive pin retention threads the tape with a higher level of reliability.

8.2.3 Bar code reader

The bar code reader is part of the library accessor, and it does not affect the slot capacity. The bar code reader provides inventory feedback to the host application, operator panel display, and web user interface (web UI) by reading cartridge bar code labels. The library stores the customized inventory data in memory.

8.2.4 Cartridge storage

The TS3200 tape library has four removable magazines in the library. The total number of cartridge slots is 48. The right side cartridge magazine and the left side cartridge magazine can each hold up to 24 cartridges.

The maximum native storage capacity is 120 TB with Ultrium 6 tape drive, 72 TB with Ultrium 5 tape drive, and 38.4 TB with the IBM Ultrium 4 tape drive installed. The 3 slot I/O station is part of the left side magazine. The magazines can be released by using the operator control panel or the web UI. Magazine access is password-protected.

Figure 8-6 shows the right side magazines.



Figure 8-6 Right side magazines

When the magazines are filled with cartridges, the web UI can be used to see which cartridges are stored in which storage slot location, as shown in Figure 8-7.

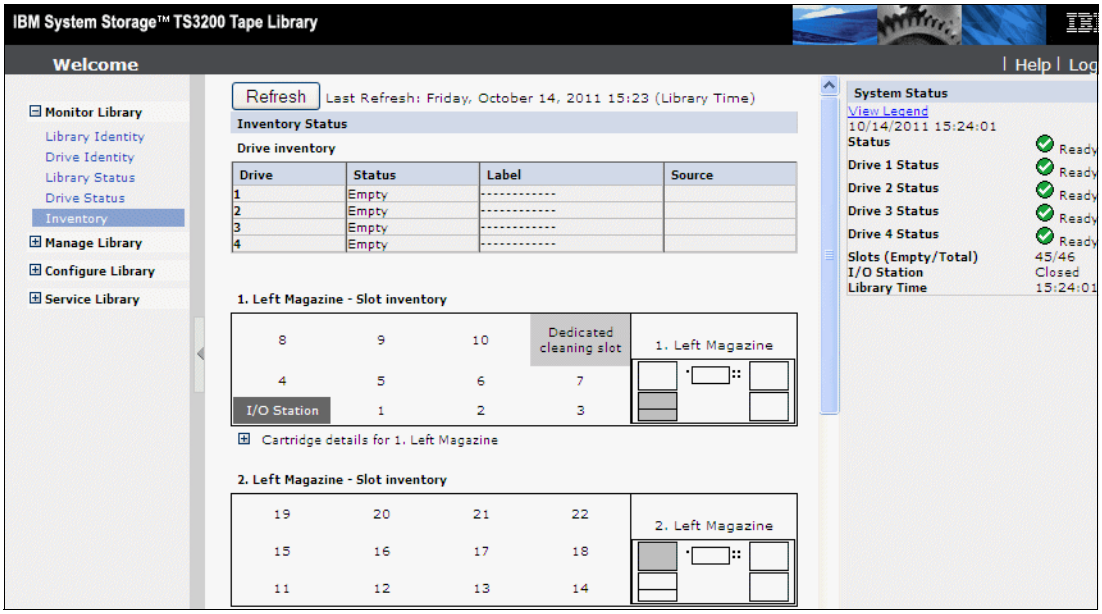


Figure 8-7 Inventory of the left magazine using the web UI

Figure 8-8 shows the left side magazines with the I/O station on the lower left side.

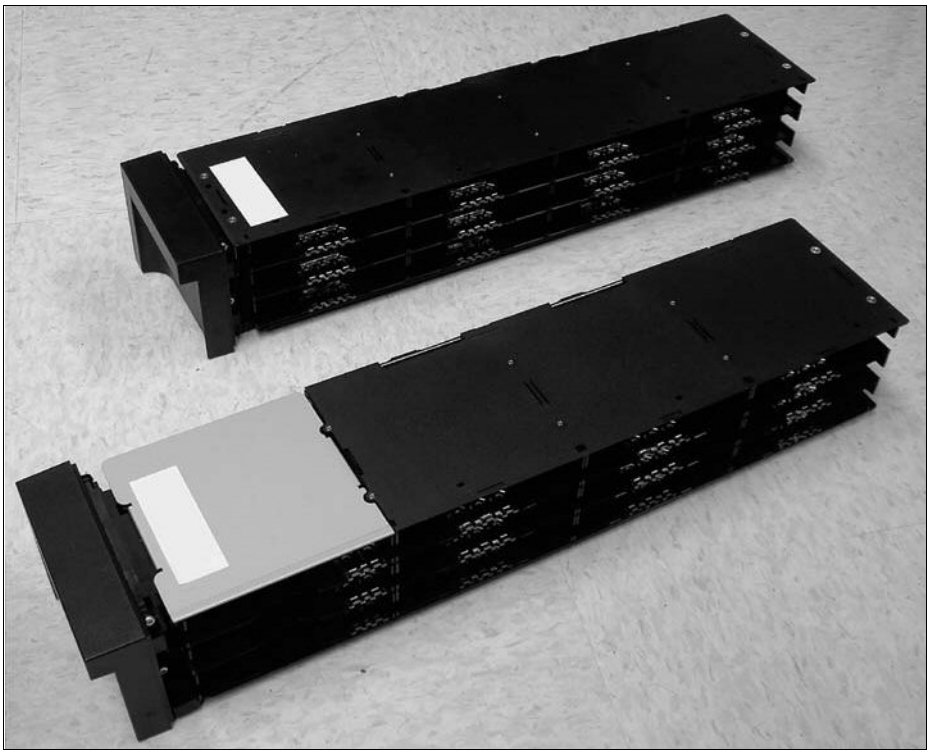


Figure 8-8 Left side magazine

In Figure 8-9, you can see the lower left side magazine with the I/O slot opened.

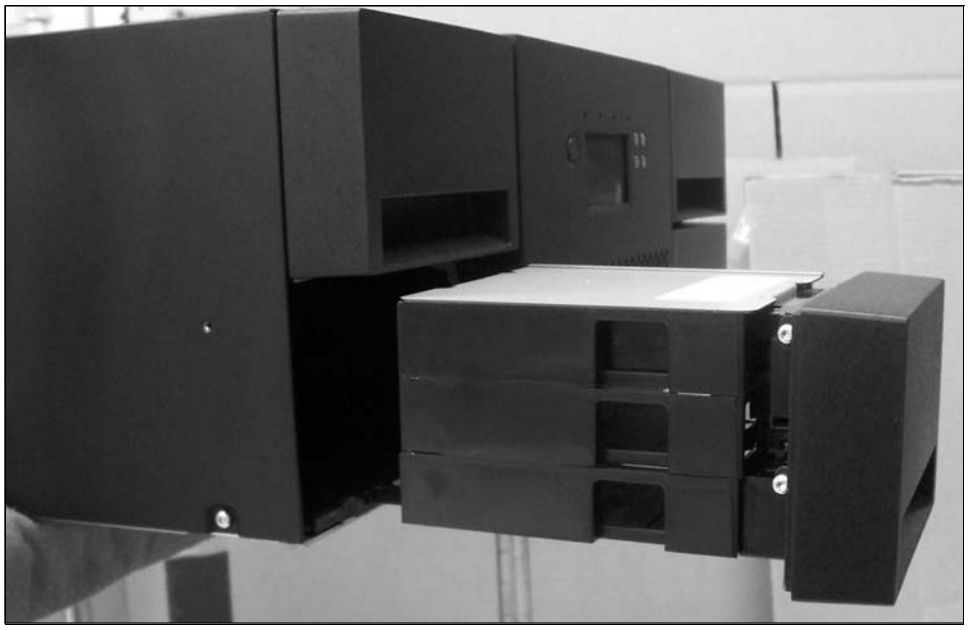


Figure 8-9 I/O station in the left side magazine

8.3 IBM LTO Ultrium tape drives

This library supports Ultrium 4, Ultrium 5, and Ultrium 6 tape drives. Each tape drive in the library is packaged in a drive sled. The drive sled is a CRU and is designed for quick removal and replacement in the library. This section summarizes the characteristics of the LTO-6 Full-High and Half-High tape drives.

The Ultrium 6 Full-High tape drive supports the 8 Gbps Fibre Channel with two LC Fibre Channel connectors.

The Ultrium 6 Half-High tape drive supports the following connectors:

- 6 Gbps SAS with dual-port SFF-8088 SAS connectors
- 8 Gbps Fibre Channel with two LC Fibre Channel connectors

For more information about LTO tape drives, see Chapter 2, “Overview of IBM LTO Ultrium tape drives” on page 41.

8.3.1 Ultrium 6 tape drives

The IBM LTO Ultrium 6 tape drive is the sixth-generation LTO Ultrium tape drive in the IBM LTO Ultrium family of products. The Ultrium 6 tape drive in the TS3200 tape library offers significant improvements over the Ultrium 5 tape drive. Like the IBM Ultrium 5 tape drive, the IBM Ultrium 6 tape drive includes the electronics and logic for reading and writing data, controlling the tape drive, managing the data buffer, and handling error recovery procedures. The LTO-6 tape drive is designed as a CRU and can easily be replaced if necessary.

Cartridge compatibility

The Ultrium 6 drive uses the IBM LTO Ultrium 2.5 TB Data Cartridge and is compatible with the cartridges of its predecessors, the IBM Ultrium tape drive Generation 5 and Generation 4. The drive performs the following functions:

- Reads and writes Ultrium 6 cartridges to Ultrium 6 format, including WORM and data encryption.
- Reads and writes Ultrium 5 cartridges to Ultrium 5 format, including WORM and data encryption.
- Reads but does not write Ultrium 4 cartridges, including WORM.
- Does not read or write Ultrium 3, Ultrium 2 and Ultrium 1 cartridges.

The drive reads tapes that were written by other licensed Ultrium 4, Ultrium 5, and Ultrium 6 tape drives, and writes to tapes that can be read by other licensed Ultrium 5 and Ultrium 6 tape drives. In addition to using the IBM LTO Ultrium Data Cartridge with up to 2.5 TB capacity, the drive offers read and write capability for all certified LTO Ultrium tape cartridges.

Platform support

The value of the TS3200 tape library can be increased by managing it with tape management solutions, such as IBM Tivoli Storage Manager or other, third-party, storage software. The TS3200 tape library is supported on the following platforms:

- IBM platforms:
  - Power Systems:
    - AIX V5.3 TL7 and above
    - i 6.1.1-7.1
  - Flex Systems (LTO-6 HH)
  - System p
  - System i
  - System x
  - System z Linux
  - Supported Microsoft and Linux platforms
- Other vendor platforms:
  - Oracle: Solaris 10 and 11
  - Hewlett Packard: HP-UX 11iV3
  - Microsoft Corporation:
    - Microsoft Windows Server 2008
    - Microsoft Windows Server 2012
  - Linux:
    - Red Hat Advanced Server Enterprise Linux 4.6-6.1
    - SUSE Enterprise Server 10 and 11

Performance highlights

If applications that are highly dependent on tape-processing speed are used, the advantage of the significant performance improvements that are provided by this tape drive can be realized. Table 8-3 shows the performance characteristics of the LTO-6 tape drive.

Table 8-3 Performance characteristics

Performance characteristics	Ultrium 6 tape drive
Native data rate	160 MBps (with Ultrium 6 media)
Maximum Interface Transfer Rate (maximum sustained with maximally compressible data)	550 MBps (SAS) 745 MBps (FC)
Interface Burst transfer rate	600 MBps (SAS) 800 MBps (FC)
Nominal load-to-ready time	12 seconds
Nominal unload time	17 seconds (FH) 22 seconds (HH)
Average rewind time	42 seconds (FH) 62 seconds (HH)

By using the built-in data-compression capability of the tape drive, greater data rates than the native data transfer rate can be achieved. However, the actual throughput is a function of many components, such as the host system processor, disk data rate, block size, data compression ratio, SCSI bus capabilities, and system or application software.

For more information about LTO-6 tape drives, see “IBM LTO Ultrium 6 library drives” on page 84.

8.3.2 Path failover

The TS3200 supports Path Failover feature. Path Failover is a combination of two previous features: Control Path Failover and Data Path Failover.

The device driver Path Failover support configures multiple physical control paths to the same logical library within the device driver and provides automatic failover to an alternative control path when a permanent error occurs on one path. This is not apparent to the running application.

8.3.3 Encryption

The IBM TS3200 tape library supports data encryption with LTO 6 tape drives. The following modes of encryption are supported:

- System Managed (available for AIX, Linux, Solaris, and Windows)
- Library Managed (available for OS/400, i5/OS, AIX, Linux, HP-UX, Solaris, and Windows)
- Application Managed (IBM Tivoli Storage Manager)

For LTO Ultrium 6, Transparent LTO encryption feature is required for enabling encryption. The IBM Security Key Lifecycle Manager is required for enabling System Managed and Library Managed encryption.

The installation of an Ultrium 6 tape drive with encryption might require code updates for IBM Power Systems, and supported open systems devices drivers or storage management software. An update of the open systems device drivers can be obtained from the Fix Central download portal by accessing the following website.

http://www.ibm.com/support/fixcentral

For more information about Encryption, see 2.2, “Tape encryption overview” on page 67.

8.3.4 Linear Tape File System

The TS3200 supports IBM Linear Tape File System (LTFS) Library Edition and IBM LTFS Storage Manager software.

IBM LTFS provides software to manage, monitor, archive, and restore files. LTFS is the first file system that works with the multiple partitioning that is available on LTO Ultrium 6 and LTO Ultrium 5 tapes drives and brings a new level of use and portability to open systems tape storage.

This storage software helps to reduce complexity in data management and access time through the enablement of a self-describing tape that includes a simple file index. LTFS allows files and directories to be shown on the desktop, directory listing, and to drag-and-drop file to and from tape. It also supports data exchange and has a simple one-time installation.

IBM LTFS LE allows the TS3200 tape library to be mounted and viewed as a single file system with the individual tape cartridge viewed as subdirectories within the file system. It is the perfect solution for those in the Media and Entertainment industry and other fields that need massive data storage on tape for on retention periods, such as banking, scientific research, and government sectors.

IBM LTFS Storage Manager Edition provides storage lifecycle management of (multimedia) files and resource management by using IBM LTFS LE, which reduces digital content archive software licensing costs while reducing video tape cartridge costs. LTFS Storage Manager provides a tool that can use metadata to arrange, search, and manage files at the user’s convenience according to the policies they decide.

For more information about LTFS LE, see this website:

http://www.ibm.com/tape/ltfs

For more information about LTFS, see *IBM Linear Tape File System Installation and Configuration*, SG24-8090

8.3.5 Notifications

The TS3200 has the following options available for sending notifications to the host:

- Simple Mail Transfer Protocol

  Simple Mail Transfer Protocol (SMTP) automatically sends an email that contains event information to the email addresses that is specified whenever an event of a certain level occurs.

- Simple Network Management Protocol

  Simple Network Management Protocol (SNMP) is a set of protocols for managing complex networks. SNMP works by sending messages called protocol data units (PDUs) to various parts of a network. Agents, which are SNMP-compliant devices that store data about themselves in Management Information Bases (MIBs) and return this data to the SNMP requesters, such as the host's monitoring application.

8.4 Physical attachments

The TS3200 tape library with LTO Ultrium 6 tape drives are available with the following interfaces:

- Native Fibre Channel 8 Gbps
- SAS 6 Gbps

Designed for tape automation, the TS3200 tape library can be attached to the following servers:

- IBM BladeCenter
- IBM Power Systems
- IBM System p
- IBM System i
- IBM System x
- IBM System z
- Advanced Micro Devices (AMD)
- Hewlett Packard
- Intel (x86 and x86_64)
- Oracle

For more information about the latest supported servers, see the IBM System Storage Interoperation Center (SSIC) website:

http://www.ibm.com/systems/support/storage/config/ssic/

8.4.1 Fibre Channel interface

Ultrium 6 Fibre Channel tape drives use LC duplex fibre optic cables. The maximum distances that a library supports on a Fibre Channel link are determined by the link speed, the type of fibre (50-micron or 62.5-micron), and the device to which the library is attached.

Figure 8-10 shows the rear of the FC Half-High tape drive.

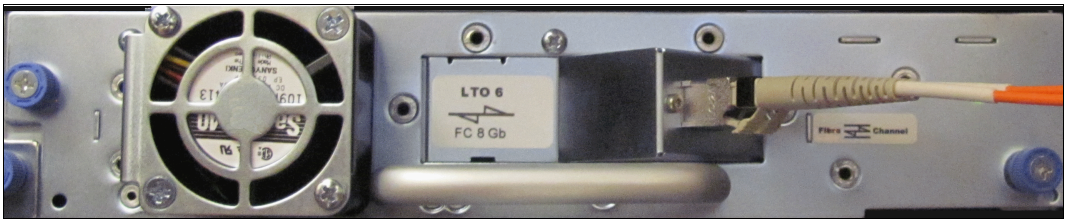


Figure 8-10 Rear of the FC Half-High tape drive

Figure 8-11 shows the rear of the FC Full-High tape drive.

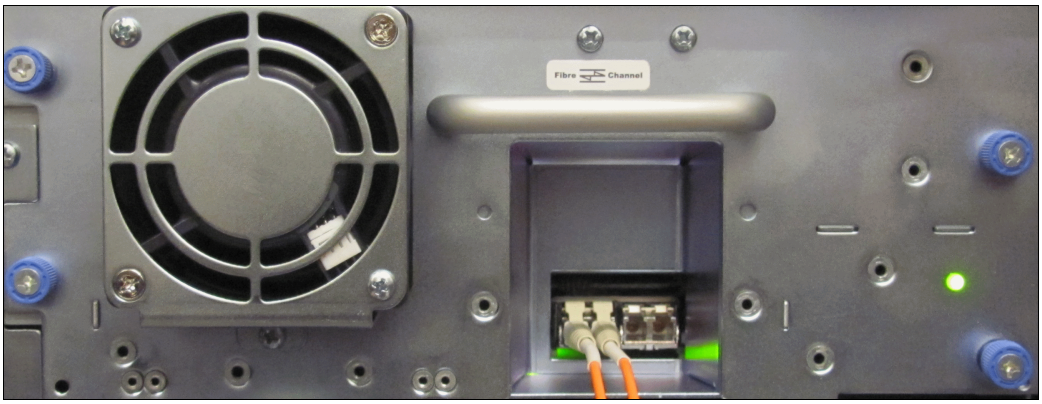


Figure 8-11 Rear of the FC Full-High tape drive

For more information about Fibre Channel interface, see “Fibre Channel” on page 63.

HBA support

Make sure that the FC HBA of your server is supported. Check the IBM HBA support in the System Storage Interoperability Center (SSIC):

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

Important: When Fibre tape drives are connected to a Fibre HBA on the host server, make sure the Fibre Channel Tape Support option is enabled on the Fibre HBA so that proper class 3 error recovery is performed on the Fibre Channel. See the HBA manufacturer for more information about how to set this option.

8.4.2 SAS interface

The IBM Ultrium 6 Half-High tape drives come with two SFF-8088 interfaces on the back of the drive. For more information about SAS, see “Serial-attached SCSI history” on page 59.

Figure 8-12 shows the back side of the SAS Half-High tape drive with two SFF-8088 interfaces.

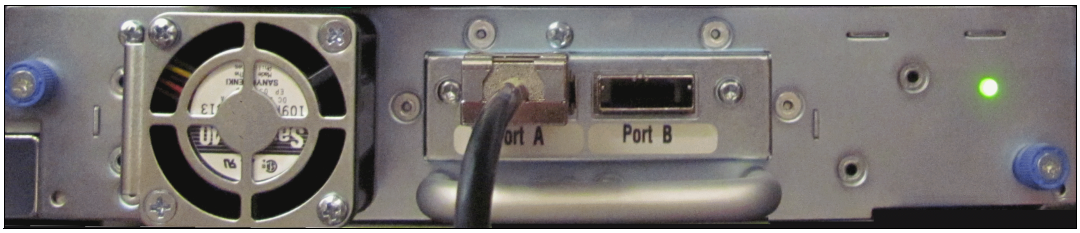


Figure 8-12 Back side of the SAS Half-High tape drive (V2)

HBA support

Verify that the HBA of your server is supported. Check the IBM interoperability matrix at the System Storage Interoperation Center (SSIC):

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

8.5 Media

To ensure that your IBM Ultrium tape drive conforms to the IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. You can use other LTO-certified data cartridges, but they might not meet the standards of reliability that are established by IBM.

8.5.1 Data cartridges

All sixth generations contain ½-inch, dual-coated, metal-particle tape. Table 8-4 lists the native data capacity of Ultrium data cartridges.

Table 8-4 Ultrium native capacity

Data cartridge	Native data capacity
Ultrium 6 and Ultrium 6 WORM	2.5 TB (6.25 TB at a 2.5:1 compression ratio)
Ultrium 5 and Ultrium 5 WORM	1.5 TB (3.0 TB at a 2:1 compression ratio)
Ultrium 4 and Ultrium 4 WORM	800 GB (1.6 TB at a 2:1 compression ratio)
Ultrium 3 and Ultrium 3 WORM	400 GB (800 GB at a 2:1 compression ratio)
Ultrium 2	200 GB (400 GB at a 2:1 compression ratio)
Ultrium 1	100 GB (200 GB at a 2:1 compression ratio)

Table 8-5 shows the compatibility among the six types of Ultrium cartridges.

Table 8-5 Ultrium data cartridge compatibility

IBM Ultrium tape drive	IBM TotalStorage LTO Ultrium Data Cartridge					
	2.5 TB (Ultrium 6)	**1.5 TB (Ultrium 5)**	**800 GB (Ultrium 4)**	**400 GB (Ultrium 3)**	**200 GB (Ultrium 2)**	**100 GB (Ultrium 1)**
Ultrium 6	Read/Write	Read/Write	Read only			
Ultrium 5		Read/Write	Read/Write	Read only		
Ultrium 4			Read/Write	Read/Write	Read only	
Ultrium 3				Read/Write	Read/Write	Read only
Ultrium 2					Read/Write	Read/Write
Ultrium 1						Read/Write

For more information about tape cartridges, see 2.1.4, “Tape cartridge” on page 48.

Write Once Read Many media

Certain records retention and data security applications require a WORM method for storing data on tape. To meet this data storage requirement, a WORM feature is available on IBM LTO Ultrium generation 3, 4, 5, and 6 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and by using a special WORM tape cartridge.

A specially formatted WORM tape cartridge is required because standard Read/Write media are incompatible with the WORM feature. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique Cartridge Memory (CM) chip serial number and the unique tape media serial number.

For more information about WORM media, see “WORM tape format” on page 47.

8.5.2 Cleaning cartridges

A specially labeled IBM LTO Universal Ultrium Cleaning Cartridge cleans the drive in your library.

The drive determines when a head needs cleaning and communicates this information to the library. When the cleaning is finished, the drive ejects the cartridge, and the picker takes the cartridge and places it back in any storage slot. To remove a cleaning cartridge, export it from the library.

The IBM Cleaning Cartridge is valid for 50 uses. The LTO-CM chip of the cartridge tracks the number of times that the cartridge is used.

For more information about Cleaning Cartridges, see “Specifications for cleaning cartridges” on page 55.

8.5.3 Cartridge memory chip

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip. This chip contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), and statistical information about the use of the cartridge.

The LTO-CM also helps to determine the reliability of the cartridge by storing data about its age, the number of times it was loaded, and the number of errors it has accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the Ultrium 6 Tape Cartridge Memory Chip is 16320 bytes.

For more information about the LTO-CM, see “Cartridge memory” on page 52.

8.6 Specifications

The TS3200 tape library is a medium-sized tape library. Its dimensions are described next.

8.6.1 Physical specifications

Table 8-6 lists the physical specifications for the library.

Table 8-6 Physical specifications

Specification	Measurement
Height	Rack mount 175.2 mm (6.9 in), stand-alone 185.2 mm (7.3 in)
Width	447.5 mm (17.6 in.)
Depth	Rack mount 740 mm (29.13 in), stand-alone 810 mm (31.9 in)
Weight with 1 drive and without media	21.32 kg (47 lbs.)
Weight with media	31.71 kg (69.9 lbs.)

Specification	Measurement
Specification	4U library

8.6.2 Power specifications

Table 8-7 lists the power specifications for the library.

Table 8-7 Power specifications

Specification	Measurement
AC power voltage	100-127 VAC; 200-240 VAC (4 - 2 A)
Line frequency	50-60 Hz

8.7 Feature codes

The TS3200 tape library can be ordered with the optional features that are listed in Table 8-8. For more information, see the TS3200 tape library Model page at this website:

http://www.ibm.com/systems/storage/tape/ts3200/index.html

Table 8-8 Optional features

Feature code	Description
1682	Path Failover (automatic data path and control path failover)
5400	SAS/Mini-SAS 4X Interposer
5402	2.0M SAS/Mini-SAS 1x Cable
5500	Mini-SAS/Mini-SAS 4X Interposer
5502	2.0M Mini-SAS/Mini-SAS 1x Cable
5604	4.5 m (14.8 ft.) VHDCI/HD68 SCSI Cable
5610	10 m (32 ft.) VHDCI/HD68 SCSI Cable
5900	Transparent LTO Encryption. Provides license keys to enable SME and LME
6013	13 m LC-LC Fibre Channel Cable
6025	25 m LC-LC Fibre Channel Cable
7002	Rack Mount Kit with Power Cord
7703	OEM - No IBM Logo
8002	Universal Cleaning Cartridge
8106	Right-side magazine set
8107	Left Upper 4U magazine
8108	Left Lower 4U magazine
8143	Ultrium 4 Full-High LVD SCSI tape drive
8144	Ultrium 4 Full-High Fibre Channel tape drive
8145	Ultrium 4 Full-High SAS tape drive

Feature code	Description
8148	Ultrium 4 Half-High Fibre Channel Drive Version 2
8149	Ultrium 4 Half-High SAS Drive Version 2
8244	Ultrium 5 Full-High Fibre Channel Drive
8245	Ultrium 5 Full-High SAS Drive
8247	Ultrium 5 Half-High SAS Drive
8248	Ultrium 5 Half-High Fibre Drive
8344	Ultrium 6 Fibre Channel Drive
8347	Ultrium 6 Half-High SAS Drive
8348	Ultrium 6 Half-High Fibre Channel Drive
8405	Data Cartridge (Generation 4) 5-packs
8505	Data Cartridge (Generation 5) 5-packs
8605	Data Cartridge (Generation 6) 5-packs
9001	Driveless Library Unit
9210	Attached to HP-UX System
9211	Attached to Oracle Solaris System
9212	Attached to Windows System
9215	Attached to Linux System
9400	Attached to i5/OS or OS/400 System
9600	Attached to AIX System
9800-9847	Power cord (different feature code for each country)
9848	Additional Rack to Power Distribution Unit (PDU) Line Cord

9

IBM TS3310 tape library

The IBM TS3310 tape library (TS3310 tape library) is a highly expandable IBM Ultrium LTO library. You can start small with a 5-U base unit (Model L5B), which is available in desktop or rack-mounted configurations. The base unit contains the library control module, fixed tape cartridge storage of 35 slots, a configurable I/O station of 6 slots, a touchscreen display, and cartridge handling robotics. The base unit also includes up to two LTO Ultrium 6, Ultrium 5, or Ultrium 4 tape drives. As your need for tape backup expands, you can add 9-U Model (E9U) expansion modules. Each E9-U expansion module can accommodate up to four LTO Ultrium 6, Ultrium 5, or Ultrium 4 tape drives; additional storage slots; a configurable I/O station of 12 slots, and redundant power supply. The entire system grows vertically. Configurations include the 5U base library module alone or with up to four 9U modules.

The TS3310 tape library offers a broad range of configuration possibilities. The smallest configuration includes a base unit with one to two LTO-6, LTO-5, or LTO-4 tape drives, 87.5 TB of native tape storage (35 slots), and 6 I/O slots. This configuration can be upgraded to a fully configured rack-mounted library 41-U high with up to 18 LTO-6, LTO-5, or LTO-4 tape drives with over 1022 TB of native tape storage and up to 54 I/O slots.

The Ultrium LTO-6, LTO-5, and LTO-4 Fibre Channel and LTO-4 serial-attached SCSI (SAS) drives in the TS3310 tape library configuration support application-managed encryption (AME), system-managed encryption (SME), and library-managed encryption (LME).

This chapter includes the following topics:

- Product description
- Library expansion
- Front panel components
- Rear panel components
- Interior components
- Optional features
- Library management
- Multipath architecture
- Working with logical libraries
- Supported environments
- Specifications
- Feature codes
- Publications

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9.1 Product description

The IBM TS3310 tape library is a highly modular, vertically scalable library design offering with the following features and support:

- A 5-U desktop or rack-mounted base module that provides up to two IBM Ultrium 6, Ultrium 5, or Ultrium 4 Full-High tape drives, 35 storage slots, and six I/O slots.
- Installation of up to four 9-U expansion modules in each one, which provides up to four IBM Ultrium 6, Ultrium 5, or Ultrium 4 Full-High tape drives and 92 storage slots, 12 of which you can optionally configure as I/O slots.
- IBM Ultrium 6 tape drive support for an 8 Gbps dual port Fibre Channel, which can be mixed in the physical library.
- IBM Ultrium 5 tape drive support for an 8 Gbps dual port Fibre Channel, which can be mixed in the physical library.
- IBM Ultrium 4 tape drive support for a 4 Gbps Fibre Channel and 3 Gbps SAS, which can be mixed in the physical library.
- Support of a connection of the library internal Ethernet interface to the Ethernet interface of each drive.
- Support for remote management through a web interface. Local management is done through a color touch panel.
- Command-line interface support.
- IBM patented multipath architecture with logical library support to share the library between multiple homogeneous or heterogeneous systems or applications.
- Supports media partitioning and self-describing tape with Linear Tape File System (LTFS) Library Edition and LTFS Storage Manager software.
- Support for a wide range of systems including IBM System z, IBM Power Systems (p6 and newer), IBM System p (p5 and earlier), pSeries, System x, xSeries, System i, iSeries, Intel, Hewlett-Packard (HP), and Oracle.
- Native Storage Management Initiative Specification (SMI-S) support.
- A bar code reader.

Optionally, you can install the following features:

- Path failover for control paths and data paths
- Capacity-on-Demand to non-disruptively provide extra capacity
- Transparent LTO encryption
- Advanced Reporting
- Redundant power supplies for each module
- Rack mounting

A fully expanded TS3310 tape library today occupies 41U of rack space and a potential maximum of 409 storage slots with the following storage:

- 327.2 TB of storage on Ultrium 4 media at native capacity (654.4 TB at a 2:1 compression ratio)
- 613.5 TB of storage on Ultrium 5 media at native capacity (1.227 PB at a 2:1 compression ratio)
- 1022.5 TB of storage on Ultrium 6 media at native capacity (2.556 TB at a 2.5:1 compression ratio)

All configurations require one TS3310 tape library Model L5B base module. Expansion is provided through the addition of the TS3310 tape library Model E9U expansion modules.

The TS3310 tape library supports all the following encryption methods:

- Application-managed encryption is available at no charge.
- Library-managed encryption is available with feature codes FC5900.
- System-managed encryption is available with feature codes FC5900.

9.1.1 TS3310 tape library Model L5B (Machine Type 3576)

The base module (as shown in Figure 9-1), offers the following standard features:

- A library control module with a remote management interface
- 35 storage slots
- Six I/O slots (configurable as storage slots if the library is expanded)
- A color, touch-sensitive window operator panel for local management
- Cartridge handling robotics
- IBM patented multipath architecture with logical library support to allow the control of the library by one or multiple systems through multiple paths
- Native SMI-S 1.2 support
- Up to two Ultrium 6 or Ultrium 5 or Ultrium 4 Full-High tape drives
- A power distribution unit (PDU)

  A second PDU is optionally available for redundancy.
- Enablement of path failover for control paths and data paths through a chargeable license
- Licensing to enable the use of up to 82 storage slots (more storage slots beyond the 35 present in the base module require an expansion module)

You can install the base module, as shown in Figure 9-1, as a desktop, deskside, or frame-mounted device.



Figure 9-1 Front view of TS3310 tape library Model L5B

9.1.2 TS3310 tape library Model E9U (Machine Type 3576)

You can stack an expansion module above or below the base module (as shown in Figure 9-2 on page 251). This configuration includes the following features:

- 92 storage slots including 12 I/O slots.

  The I/O slots can be configured to be storage slots.
- Up to four Ultrium 6 or Ultrium 5 or Ultrium 4 Full-High tape drives.
- A PDU. A second optional PDU is available for redundancy.
- 46 of the total slots in the first expansion module that are immediately usable (because of the licensing that was provided with the base module).

  The rest can be non-disruptively enabled by installing a license for Capacity Expansion (FC1640). Subsequent expansion modules require Capacity Expansion features to enable the use of storage slots in increments of 46.
- A 5-U base module and one 9-U expansion module that can be installed as a deskside device or in a rack.

Attention: If two or more 9U expansion modules are installed, they must be rack-mounted.



Figure 9-2 Front of TS3310 tape library 41U

9.2 Library expansion

As described earlier in this chapter, the base library can be scaled up with the addition of expansion modules. Regardless of the number of expansion modules, the TS3310 tape library uses a single robust flow-through design robotic system to access all drives and media. It never requires complex pass-through ports or elevator systems, which removes the need for expensive duplication of robotics and control electronics with each library expansion. It also results in more reliable operations.

Expansion modules can be installed above or below the base module, and the process takes approximately 2.5 hours to complete. When multiple expansion modules are used, they can be installed around the base module, if preferred. However, it is recommended that the base

module be kept at a user-friendly access height. For more information about the recommended library configuration setup, see *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477.

Tip: Consider leaving a minimum clearance of 6 inches above the library for Service Clearance when the library is installed in a rack. Service activities might require removing the top cover.

Figure 9-3 shows the expansion path. The addition of each expansion module provides another 92 storage slots, which are enabled through the use of Capacity-on-Demand licenses. The base module ships with licensing for 82 slots. Therefore, when you add the first expansion module, half the slots are available immediately without the requirement to acquire more licenses.

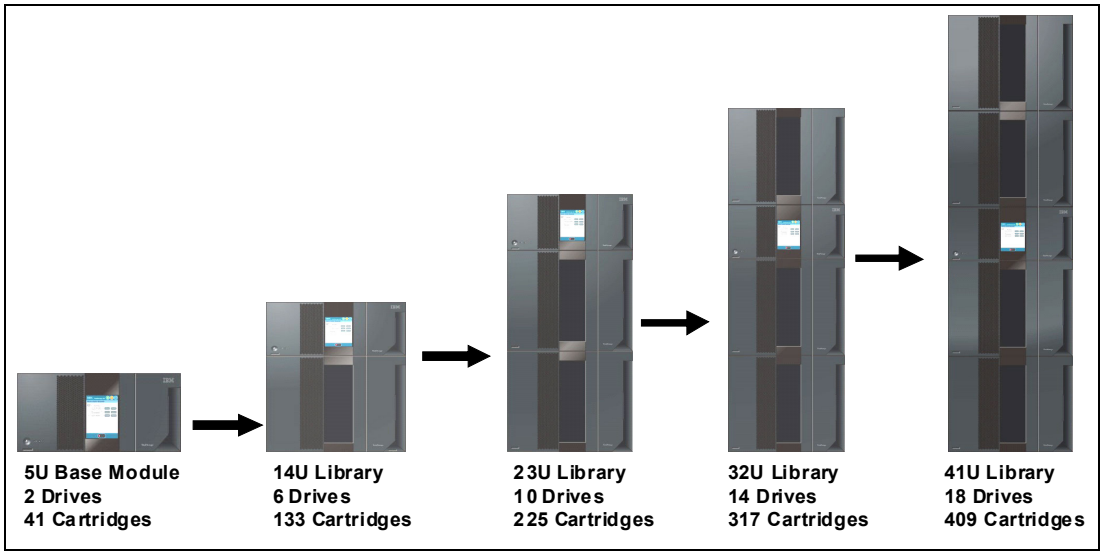


Figure 9-3 TS3310 tape library expansion path

You can configure the I/O slots in each module as a group to operate as I/O slots or storage slots (at least one group must operate as I/O slots). This method provides a high degree of flexibility. For example, in a library configuration of one L5B base unit and one 9EU expansion unit, the following combinations are possible:

- A total of 6 I/O slots (all in the base module)
- A total of 12 I/O slots (using the slots in the expansion module)
- A total of 18 I/O slots (using the slots in the base module and the expansion module)

Expansion of the TS3310 tape library is granular and highly configurable. Table 9-1 shows the configuration options that are available as the base module expands with an M1 robot assembly installed.

Table 9-1 Library configurations showing I/O slots, storage slots, and drive combinations

Library configuration	Number of available I/O station slots[a]	Number of accessible storage slots[b]	Total slots[b]	Number of expansion license keys
5U library (control module)	6	35	41	No license key required
14U library (control module + 9U expansion module)	6, 12, or 18	76, 70, or 64	82	Without the Capacity-on-Demand feature
	6, 12, or 18	127, 121, or 115	133	One license key required to enable the full capacity of a 14U library
23U library (control module + 2 9U expansion modules)	6, 12, 18, 24, or 30	168, 162, 156, 150, or 144	174	Each license key enables full capacity of one 9U expansion module
	6, 12, 18, 24, or 30	219, 213, 207, 201, or 195	225	Two license keys required to enable the full capacity of a 23U library
32U library (control module + 3 9U expansion modules)	6, 12, 18, 24, 30, 36, or 42	258, 252, 246, 240, 234, 228, or 222	264	Two license keys enable another 92+90 slots on the two 9U expansion modules
	6, 12, 18, 24, 30, 36, or 42	311, 305, 299, 293, 287, 281, or 275	317	Three license keys required to enable the full capacity of a 32U library
41U library (control module + 4 9U expansion modules)	6, 12, 18, 24, 30, 36, 42, 48, or 54	350, 344, 338, 332, 326, 320, 314, 308, or 302	356	Three license keys enable an additional 92+90+92 slots on the three 9U expansion modules
	6, 12, 18, 24, 30, 36, 42, 48, or 54	403, 397, 391, 385, 379, 373, 367, 361, or 355	409	Four license keys required to enable the full capacity of a 41U library

a. The I/O station in the 9U expansion module contains 12 slots that can be configured as I/O or storage slots. If the 9U expansion module I/O slots are configured as I/O, the control module slots can be configured as storage slots.

b. The number of available I/O and storage slots are adjusted for the unusable slots in each configuration that are not accessible because of space restrictions, which limit the movement of the picker. The M2 picker provides another five or seven slots, depending on the library configuration and the number of Capacity Expansion license keys that are purchased. An example is a 5-U library with the M2 robot has 35 accessible slots, for a total of 41 slots.

9.3 Front panel components

Figure 9-4 on page 254 shows the front panel components of the TS3310 tape library.

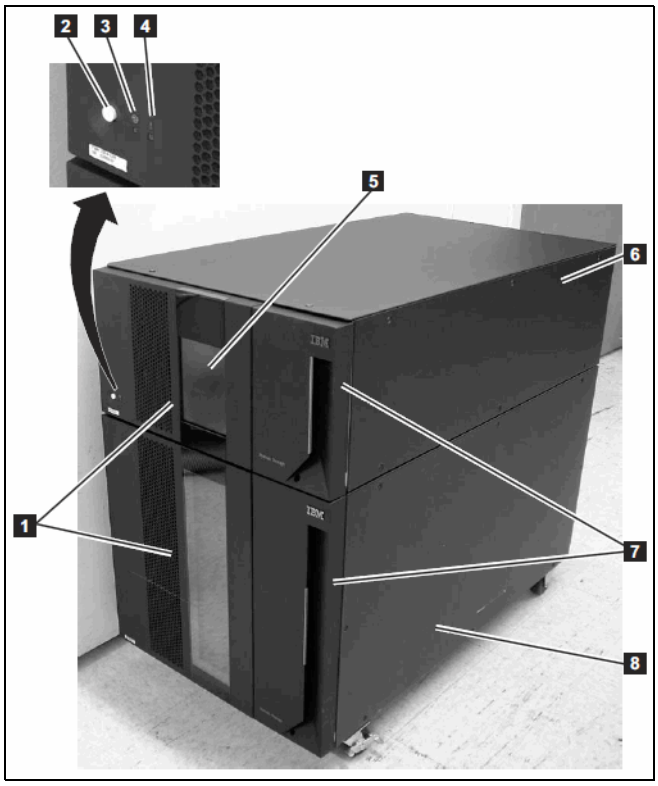


Figure 9-4 Elements visible in the front view of a 14U library configuration

The numbers in Figure 9-4 highlight the following components:

1. Access doors
2. Power button
3. Green Power ON LEDs
4. Amber Operator Intervention Alert LED
5. Operator panel
6. 5U control module
7. I/O stations
8. 9U expansion module

All library configurations include the base module. The base module contains the robotics, Library Control Blade, and touch-sensitive display. The base module also contains an I/O station, fixed storage slots, one or two tape drives, and one or two power supplies.

9.3.1 Expansion module

Similar to the control module, the expansion module also provides fixed storage slots, tape drive slots, and power supply slots. The I/O station in an expansion module can be configured as storage. If an expansion module contains only cartridges, all power is derived from the control module.

9.3.2 I/O station

I/O stations are on the front panel of the library and enable inserting and removing cartridges without interrupting normal library operations. A base module I/O station has a capacity of six cartridges. A 9-U expansion module I/O station has a capacity of 12 cartridges.

When an operator places cartridges in the I/O station, the operator panel prompts to request a logical library assignment. The operator must respond to this prompt within two minutes. Otherwise, the library assigns the tapes instead to the physical library from which the host application does not have access. All cartridges in the I/O station are assigned as a group. That is, if an operator had cartridges for several logical libraries, the cartridges must be sorted into separate groups before it is placed in the I/O station.

After an I/O station slot is assigned to a logical library, only that logical library can access that slot. The I/O station is shared among all logical libraries, but the I/O station slots are owned by one logical library at a time. In a 5-U library, the six I/O station slots cannot be configured as storage.

9.3.3 Access door

Each base module and expansion module has a door on the front panel that allows access to the internal components of the library. This door is locked by the I/O station. To open the access door, you must first open the I/O station.

Important: When any access door is opened, all in-progress motion commands stop, the picker lowers to the bottom of the library, and the library is taken offline. (The library must be put back online manually.) When the access door is closed, the library returns any media in the picker to its original storage slot.

9.3.4 Operator panel

The operator panel is the touch-sensitive display device on the access door of the control module. Library operations and service functions are performed from this display. The web User Interface (web UI) offers part of the same functionality as the operator panel from a web browser, which enables remote access to the library. For more information about the operator panel and the web UI, see 9.7, “Library management” on page 263.

9.3.5 Power button

Pressing the Power button on the front panel of a control module turns the different library components ON or OFF. However, with the Power button in the OFF position, power is still applied to the power supplies. The Power button is used during library shutdown and to manually restart the library.

9.3.6 Front panel LEDs

The following LEDs are on the front of the library to the right of the Power button:

- Green: Power on LED. Indicates that the library power is ON.
- Amber: Operator Intervention Alert LED. This LED indicates that library, drives, or media operator interventions exist. To access the operator intervention, select **Tools** → **Operator Intervention** from the operator panel or select **Service Library** → **Operator Interventions** from the web UI.

9.4 Rear panel components

Figure 9-5 shows the rear view of a 14-U (one base module and one expansion module) library and its major components.

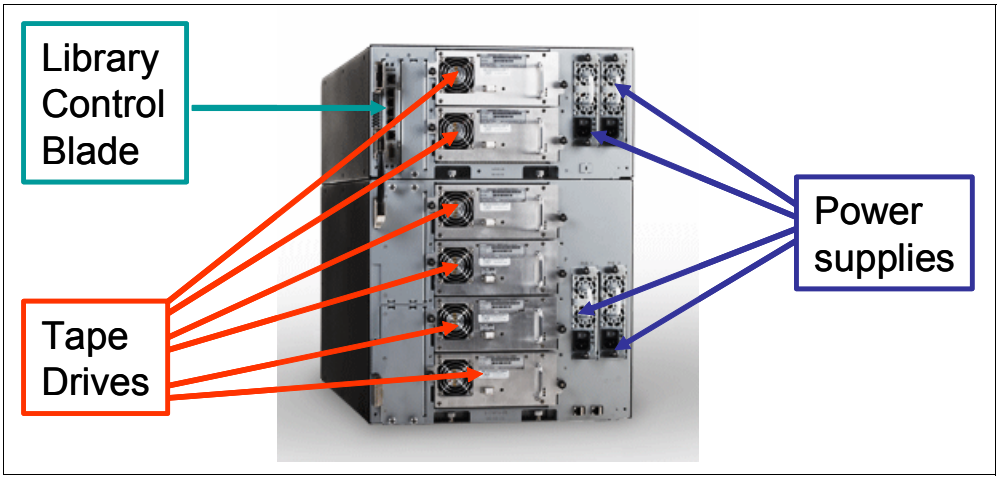


Figure 9-5 Rear panel view of 14U library

Ethernet port: The Ethernet port on the rear of the LTO-6 tape drive in the TS3310 tape library can be used to establish an Ethernet connection between the drive and the library. Feature 3470 is required in this case.

9.4.1 Library Control Blade

The Library Control Blade manages the entire library, including the operator panel and picker. It is responsible for running system tests to ensure that the library functions properly. The Library Control Blade houses the compact flash card, which stores vital product data (VPD), such as library settings and the library serial number.

The Library Control Blade indicates status with three LEDs. These LEDs indicate status by the rate at which they flash. The color of the LED identifies the area of the component that is reported.

Table 9-2 shows how to interpret the status of these LEDs.

Table 9-2 LED status

LED Color	Represents	Blade Status
Green	Processor status	► Solid ON: Processor not operating ► Solid ON for 3 seconds, and then flashes twice: LCB firmware is downloading ► 1 flash per second: Normal (Processor operating) ► 10 flashes per second: Identify mode ► Solid OFF: Processor not operating
Amber	Health status	► 1 flash per second: Main processor not operating ► Solid OFF: Normal (Blade operational)
Blue	Power control status	► Solid ON: Swap mode (LCB is powered down and can be removed) ► 1 flash per 10 seconds: Normal (LCB on) ► Solid OFF: LCB not receiving power

The combination of these LEDs and respective specific timing of being ON indicates a good or faulty status of the Library Control Blade. All three LEDs with a solid ON for more than 20 minutes indicates a bad or corrupted compact flash.

9.4.2 Tape drives

The library supports Ultrium 4 SAS and Fibre Channel Full-High tape drives, Ultrium 5 Fibre Channel Full-High tape drives and Ultrium 6 Fibre Channel Full-High tape drives. Tape drives are hot-addable, which mean the library power remains ON and operations of the existing tape drives are still active. Drives can be removed and installed without tools. The drive sled is a customer-replaceable unit (CRU).

Fibre Channel tape drives can be directly attached to a host or a storage area network (SAN). SAS tape drives can be directly connected to a host or connected to the host via the SAS Fan-out cable. Drives that are mounted in sleds are installed into tape drive slots in the rear of the library. If a tape drive slot is empty, a metal plate covers the empty drive slots to prevent debris from entering the library.

Figure 9-6 shows the back side of the LTO-6 FC tape drive with two Mini-SAS (SFF-8088) interfaces.



Figure 9-6 Back side of the LTO-6 FC tape drive

Figure 9-7 shows two Fibre tape drives, an LTO-4 single-port Fibre tape drive and an LTO-5 dual-port Fibre tape drive, as seen from the rear of the TS3310 tape library base module.

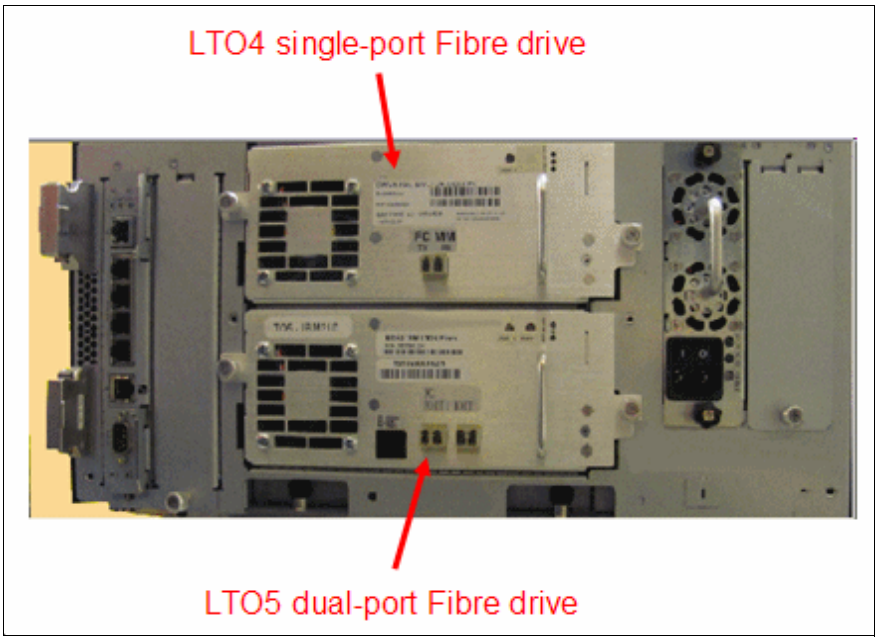


Figure 9-7 LTO-4 and LTO-5 Fibre tape drives

Tip: When connecting Fibre tape drives is connected to a Fibre HBA on the host server, make sure the Fibre Channel Tape Support option is enabled on the Fibre HBA so that proper class 3 error recovery is performed on the Fibre Channel. For more information about hot to set this option, see the HBA manufacturer.

9.4.3 Power supply

The library supports single and redundant power configurations. A single power configuration has a power supply installed in the left slot of each library module. A redundant power configuration has power supplies installed in both slots of each library module. When two power supplies are used in a single module, the power load is spread evenly over both power supplies. If one of the power supplies fails, the power load is drawn entirely from the functioning supply.

The single configuration has a single AC line input and a single DC power supply. The optional redundant configuration has dual AC line input and dual DC power supplies. A power supply can be hot-swapped if the library has a redundant power supply. A redundant power supply can be hot added. A power switch is on every power supply on a control module and an expansion module. This switch is used to remove all power from the library for emergency and service situations. Except in emergency situations, use the shutdown procedure before switching off the power switch.

The power system of the library contains the following components:

- Power supply
- An AC power cord

The power supply has three LEDs that provide status information. These LEDs, which are to the right of the power switch, are green, amber, and blue in color and indicate the following conditions:

- Green: Good AC or DC status
- Amber: Degraded status
- Blue: Fault status

9.5 Interior components

Storage columns and the robotic system are in the body of the library.

9.5.1 Storage columns

Storage columns within the library store cartridges while they are not loaded in a drive. The library contains six storage columns. One of those six columns is the I/O station. Figure 9-8 shows an example of the TS3310 tape library storage columns in the base model.

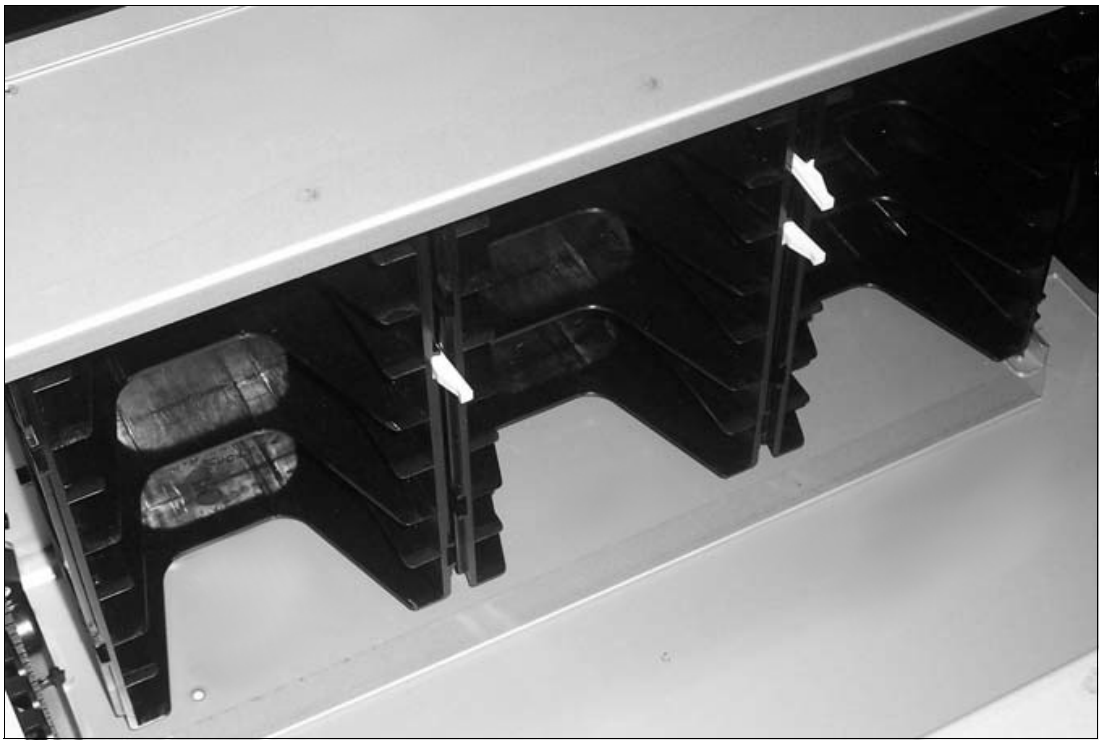


Figure 9-8 TS3310 tape library storage columns

9.5.2 Robotic system

The robotic system includes the Y-axis assembly that houses the Y motor, the picker (which is attached to the carrier), and the bar code scanner. The climber moves the robotic system within the library. The picker (robotic arm) has finger-like mechanisms that it uses to grab tape cartridges and move them to and from the I/O station, storage slots, and drives. The bar code scanner reads each cartridge bar code label and the fiducial labels that identify the types of cartridge magazines and tape drives installed in the library.

Figure 9-9 shows the latest M2 Robot assembly (which is available only on libraries with a serial number of 15000 or higher) of the TS3310 tape library. The M2 Robot assembly includes a label with the characters “M2” on it. Older libraries included what was called the M1 Robot assembly.

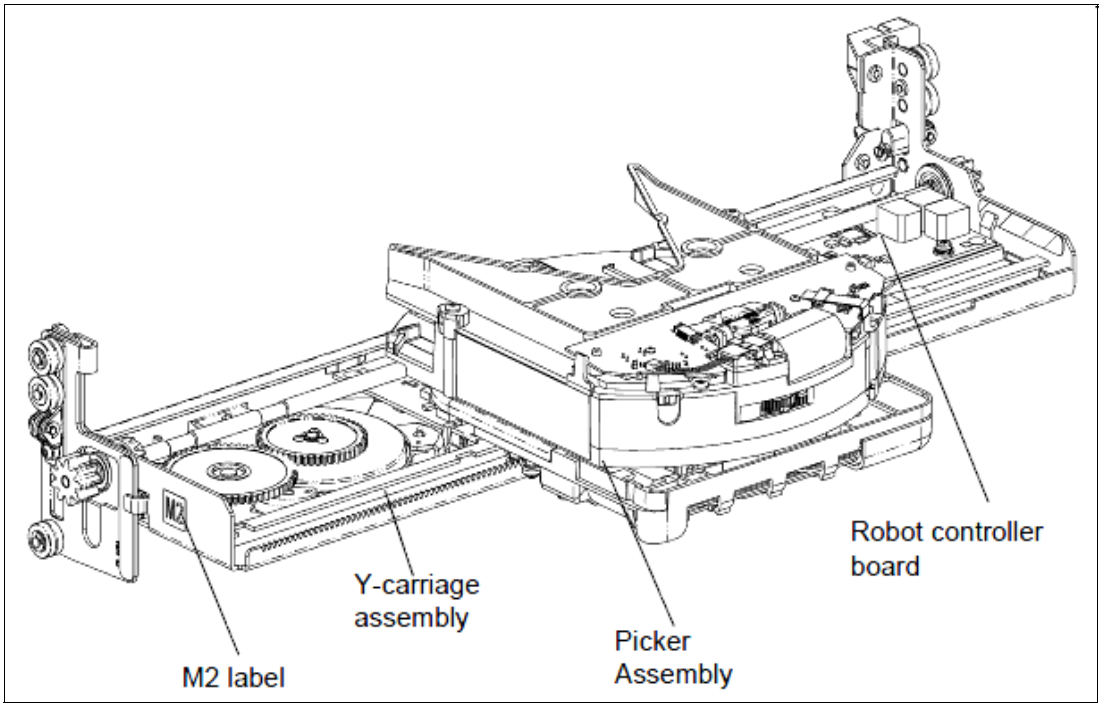


Figure 9-9 TS3310 tape library M2 Robot assembly

9.6 Optional features

The TS3310 tape library is highly configurable and enhanced functionality is available through the provision of optional features.

9.6.1 IBM Ultrium tape drives

The TS3310 tape library now incorporates the IBM LTO Ultrium 6 Full-High 8 Gbps dual-port Fibre Channel Drives, the sixth-generation LTO Ultrium tape drive in the IBM LTO Ultrium family of products. It enhances tape performance over the previous generation of IBM LTO Ultrium 5 tape drives with a native data transfer rate of up to 160 MBps. It still supports Ultrium 5 and Ultrium 4 type tape drives in a mixed configuration and attachment type. For more information, see Chapter 2, “Overview of IBM LTO Ultrium tape drives” on page 41.

The IBM Ultrium tape drive contains the electronics and logic for reading and writing data, controlling the tape drive, managing the data buffer, and handling error recovery procedures. It is a CRU and can easily be replaced if necessary.

Table 9-3 shows a comparison of some features and characteristics of the different generations.

Table 9-3 Characteristics and features

Characteristics and features	Ultrium 6 tape drive	Ultrium 5 tape drive	Ultrium 4 tape drive
Native data rate	160 MBps (with Ultrium 6 media)	140 MBps (with Ultrium 5 media)	120 MBps (with Ultrium 5 media)
Cartridge compatibility Ultrium and Ultrium WORM	LTO-6 read/write LTO-5 read/write LTO-4 read only	LTO-6 N/A LTO-5 read/write LTO-4 read/write	LTO-6 N/A LTO-5 N/A LTO-4 read/write
Cartridge capacity native/compressed	2500 GB/6250 TB	1500 GB/3000 GB	800 GB/1600 GB
Speed matching support	Yes	Yes	Yes
Channel calibration	Yes	Yes	Yes
Giant magneto-resistive head	Yes	Yes	N/A

9.6.2 Redundant power supply

The service representative can hot swap the optional redundant configuration power supplies (FC1900) without interrupting library operation. Each supply in a control module and expansion module includes its own input AC power cord. During redundant operation, each supply carries half the power load. If a power cord or power supply fails, the second supply sources the complete power load. Optionally, you can install a single power supply and power cord if redundant power is not required. The second power supply slot is physically covered in this configuration. The library can be upgraded to redundant power at a later time. In case the configuration consists of the base model and expansion units, if a second power supply is added to one model, it also should be added to the other model.

9.6.3 Feature licenses

A *feature license* controls the setting of feature-enabled flags that are based on a user input key and the library serial number that is stored in the library VPD. A unique key exists for each library that is based on an encryption of the chassis serial number and a feature code. After a feature is enabled, it cannot be disabled. The serial number of the library only can be assigned at the factory. The library uses feature licenses to enable the Capacity-on-Demand feature and the Path Failover feature.

Capacity Expansion (FC1640)

At any time, you can use the Capacity Expansion feature (FC1640) to enable the unused storage slots within a library by using a firmware license key. The TS3310 tape library Model L5B control module includes license key enablement for a total of 82 cartridges. The license key enables all of the cartridge slots in the control module and approximately half of the capacity of an added expansion module.

To enable the remaining cartridge storage slots, you must purchase the Capacity Expansion feature (FC1640) for each expansion module that you want to fully enable. For example, one Capacity Expansion feature (FC1640) is required to access and enable all available cartridge slots in a 14-U configured library (one control module and one expansion module). Two Capacity Expansion features (FC1640) are required to access and enable all available cartridge slots in a 23-U configured library (one control module and two expansion modules). For more information, see 9.2, “Library expansion” on page 251.

You can see the current configuration of the library from the operator panel by using the Capacity View home window and by using the web UI by selecting **Monitor System** → **System Summary**.

Advanced Reporting (FC1650)

Advanced Reporting (FC1650) is a licensed feature. With this feature, the TS3310 tape library can export the read and write history data of the drive, tape alerts, and entire media pool that is associated with the library by using the following report formats:

- Drive Utilization Reporting
- Media Integrity Analysis

The Advanced Reporting feature provides diagnostics and trend analysis. This licensed feature is a valuable tool that helps you identify how tape resources are used. You can easily identify whether the drive resources are not fully used so that you can reallocate jobs to decrease the backup window completion time. The Drive Utilization Report provides a clear and quantifiable method to determine if more drives are needed. For more information about the Advanced Reporting panels, see 9.7.6, “Advanced Reporting” on page 274.

Path failover (FC1682)

The Path Failover feature includes license keys for activating Control Path Failover and Data Path Failover. Path Failover is a combination of two previous features: Control Path Failover (key entered at the library user interface) and Data Path Failover (key entered at the device driver interface). A single activation key entered at the library user interface now activates both features. The Path Failover feature is available on select drives. The path failover feature includes the license keys for activating Control Path Failover and Data Path Failover. This feature is not supported on IBM System i or IBM iSeries.

Control path failover

A *control path* is a logical path into the library through which a server sends standard SCSI medium changer commands to control the logical library. Other control paths reduce the possibility that failure in one control path causes the entire library to be unavailable. Use of the Control Path Failover feature further reduces that possibility.

Data Path Failover

Data Path Failover provides a failover mechanism in the IBM device driver with which you can configure multiple redundant paths in a SAN environment. If a path or component failure occurs, the failover mechanism automatically provides error recovery to try the current operation again by using an alternative, preconfigured path without stopping the current job in progress. This feature provides flexibility in SAN configuration, availability, and management.

The license keys can be installed by using the operator panel and selecting **Setup** → **License**. Alternatively, you can use the web UI and select **Manage Library** → **Settings** → **Feature Licenses**. With the release of library code 605G and higher, you can now view the license key number on the Feature Licenses panel, as shown in Figure 9-10.

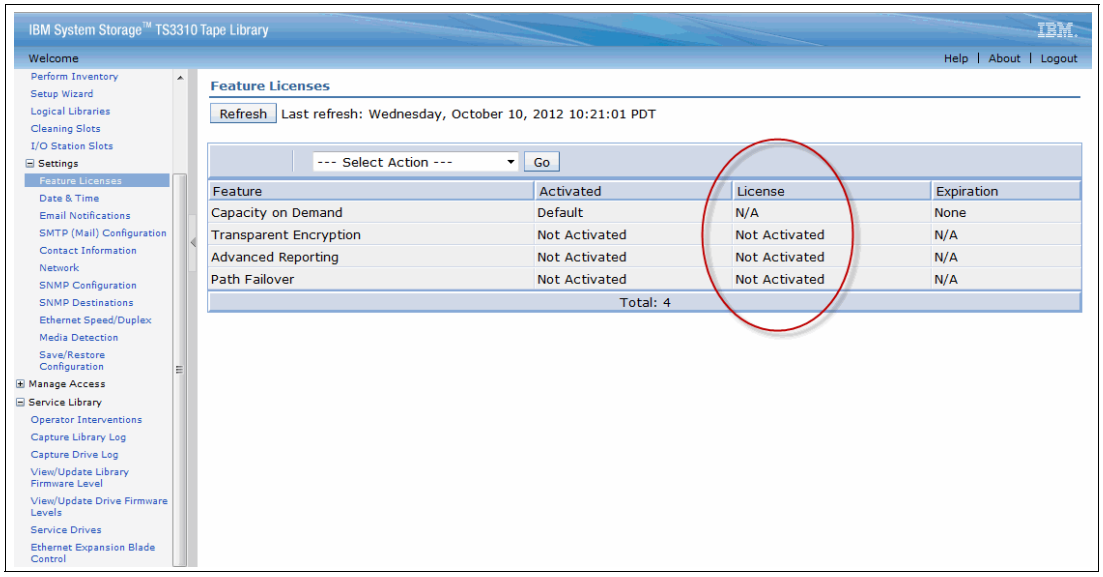


Figure 9-10 Feature Licenses panel

9.7 Library management

The library includes the following interfaces for management:

- Operator panel for local management
- Web UI for remote management
- Command-line interface (CLI)

The operator panel is on the front door of the control module. With the operator panel, operators can work locally on the library by using the touch panel. With the web UI, you can view and perform several library functions from remote sites. This interface is best viewed by using Internet Explorer 4.0 or later. The TS3310 tape library CLI is a program that is used to access the library from a CLI.

The library also is SMI-S 1.2 compliant. With this capability, Storage Resource Management Applications, such as the IBM Tivoli Storage Productivity Center, can manage the library (along with other SMI-S compliant devices, for example, SAN switches and disk arrays) from a single location.

9.7.1 Operator panel

The operator panel is physically attached to the front door of the base module. The user interface is displayed on the touch-sensitive LCD display of the operator panel for performing basic library management functions. Audible feedback, such as key click sounds, is generated when you touch a button on the touch-sensitive display.

To access the menus, you must first log in by using the keyboard display, which is shown when you touch the panel.

Tip: To use the touch-sensitive display effectively, tap lightly to make your selections.

The first display that is shown is the welcome window, as shown in Figure 9-11. The welcome window provides tabular data about the capacity of the various areas of the library. Use this window to see a quick summary of the capacity of the library.

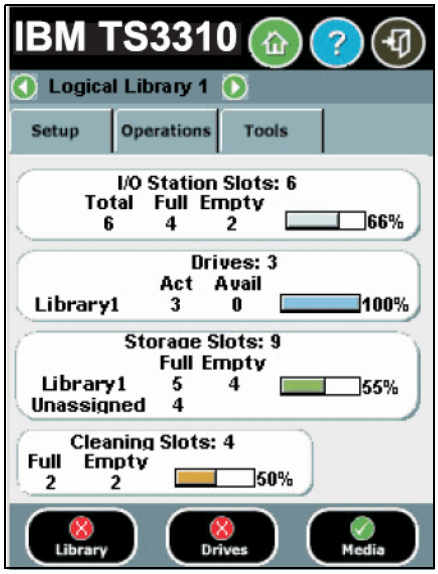


Figure 9-11 Welcome window in the operator panel

System summary and subsystem status

You can gauge the health of the library by using the following subsystem status buttons at the bottom of the home page:

- Library: Opens a library menu selection window and then opens the operator intervention window for the library.
- Drives: Opens the operator intervention window for drives.
- Media: Opens the operator intervention window for media.

These buttons provide easy access to the health of the library for faster recovery if problems occur. You can select the buttons to view detailed information about the library and to access to library subsystems.

Each button has the following states, which are indicated by color:

Good	Green
Degraded	Yellow (An operator intervention was created.)
Investigate	Red (An operator intervention was created; however, the library might still be operational.)

If users have access to more than one logical library, they can navigate to other logical libraries by using the arrows that are next to the logical library name at the top of the window. If an administrative user is logged in, a view of the physical library appears. If a user is logged in, the first logical library to which that user has access (in alphabetical order) appears.

Menus from the operator panel

The following menus organize commands into logical groups:

- Setup menu: Consists of commands that you can use to set up and configure various aspects of the library, including connectivity of logical libraries, network, physical library, users, date and time, licenses, and Simple Network Management Protocol (SNMP) trap registration.
- Operations menu: Consists of commands that you can use to change the mode of operations of the library, insert and remove cartridges, load and unload drives, move media, and shut down and restart the library.
- Tools menu: Consists of commands that you can use to maintain your library, such as viewing operator interventions, capturing a snapshot of the library, identifying ports, and updating firmware using a Field Microcode Replacement (FMR) cartridge.

Figure 9-12 shows a menu tree with all functions that are available from the operator panel interface.

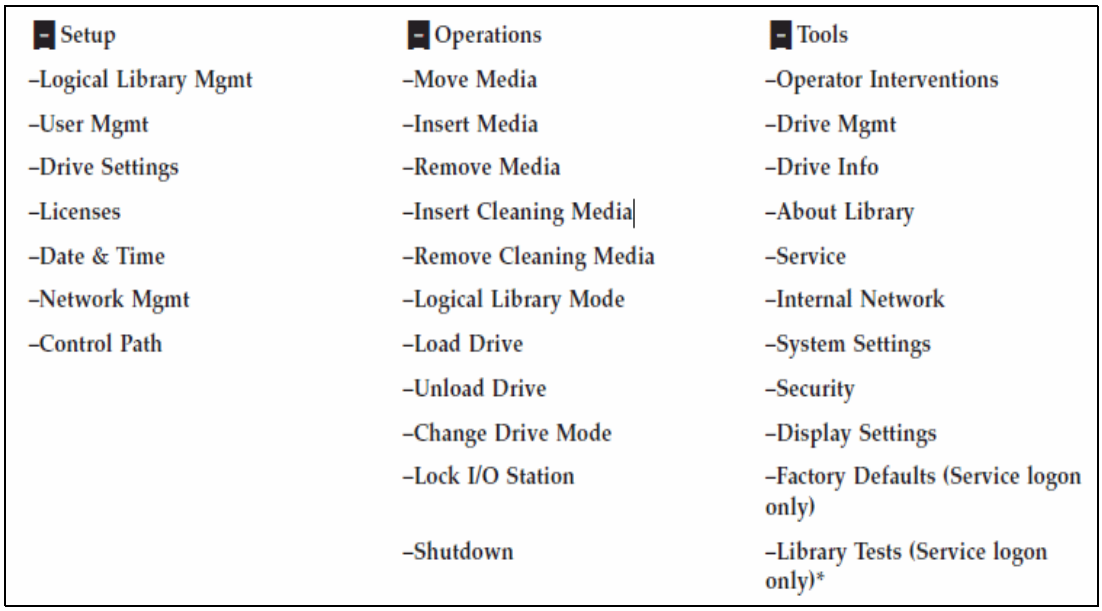


Figure 9-12 Menu tree of the operator panel

9.7.2 Web user interface

The web UI is accessible from a web browser and is best viewed by using Internet Explorer 4.0 or higher. To manage the library by using the web UI, you must set up the initial network configuration of the library from the touch-sensitive display of the operator panel.

Logging in to the web UI

To log in, you need the following initial login information:

- User: `admin`
- Password: `secure`

Attention: Before you exit the web UI, log out by clicking **LOGOUT** in the upper-right corner of any web UI window. Failure to log out can cause problems for further logins with your library.

Lightweight Directory Access Protocol support

Local authentication control is managed on the library. An administrator sets up accounts and privileges on the library. To use local authentication, a user must enter a local user name and password. Remote authentication is managed by an LDAP server. Enabling LDAP allows existing user accounts that are on an LDAP server to be integrated into the library's current user account management subsystem. User account information is centralized and shared by different applications, which simplifies user account management tasks.

Administrative users can configure and enable LDAP. After LDAP is enabled, users can access the library with LDAP or local authentication. To use LDAP authentication, a user must enter a directory service user name and password and specify an LDAP domain. To use local authentication, a user must enter only a local user name and password.

Administrative users can add, delete, and modify only local user account information. The library web client and operator panel do not allow you to create, modify, or delete user account information about an LDAP server. This procedure must be done by the directory service provider. For more information about LDAP user accounts, see your server documentation.

LDAP server guidelines

The library supports user account information in the schema that is defined by RFC 2307. For LDAP users with user privileges, access to the logical libraries is determined by group assignment on the LDAP server. Groups must be created on the LDAP server with names that correspond to the logical library names. Users with user privileges must be assigned to these groups on the LDAP server to have access to the corresponding logical libraries on the library. LDAP users with administrative privileges have access to all logical libraries and administrative functions and do not need to be assigned to logical library-related groups on the LDAP server. The following groups must be created on the LDAP server to enable remote login on the library:

- Library user group

  Assign users to this group who need user-privilege access to the library. The name of this group is in the User Group field on the **Manage Access** → **Authentication Settings** panel on the library web client.

- Partition groups

  For LDAP users with user privileges, access to library partitions is determined by group assignment on the LDAP server. Groups must be created on the LDAP server with names that match the library partition names (names must match but are not case-sensitive). Users with user privileges must be assigned to these groups on the LDAP server to have access to the corresponding partitions on the library.

- Library admin group

  Assign users to this group who need administrator-privilege access to the library. LDAP users with administrator privileges have access to all partitions and administrator functions and do not need to be assigned to partition-related groups on the LDAP server. Enter the name of this group in the Administrator Group field on the **Manage Access** → **Authentication Settings** panel on the library web client.

You must have at least one user assigned to the Library User Group and the Library Admin Group on the LDAP server to test the LDAP settings on the library. Because most users are not members of both these groups, you might need to create a special or temporary user specifically for this purpose.

Kerberos

Kerberos Authentication is a standard (RFC 1510) third-party authentication protocol that provides end-to-end security for distributed computing environments.

The web client login panel gives the user a choice between the use of local authentication or LDAP authentication. If LDAP authentication is selected, the user is prompted for the LDAP domain.

The Operator Panel login panel gives the user the choice between the use of Local authentication and Remote authentication when LDAP access is enabled. If LDAP access is disabled, the Remote authentication option does not appear on the login panel.

With Local authentication, the user name and password are stored on the library. With LDAP authentication, the user name and password are stored on a server.

Kerberos requires LDAP information, but LDAP users are not required to use Kerberos. If your library is running firmware version 600G or later, you can optionally configure Secure LDAP by using one of two methods: LDAP over SSL (LDAPS), or LDAP over TLS (StartTLS). However, you cannot use both.

Important: When LDAP is enabled, the user can choose local authentication on the login window, where the login ID and password are stored on the library. Alternatively, the user can choose LDAP authentication, where the login ID and password are stored on a server, and the user must specify the LDAP domain name. If LDAP access is disabled, the LDAP options are not displayed in the login window.

Figure 9-13 shows the TS3310 tape library Sign On window with local authentication selected.



Figure 9-13 TS3310 tape library Sign On window

Figure 9-14 shows the TS3310 tape library Sign On panel window with the LDAP authentication selected.



Figure 9-14 TS3310 tape library Sign-on panel *with LDAP authentication selected*

By using local authentication, the TS3310 tape library Welcome page (as shown in Figure 9-15) is displayed after you log in.

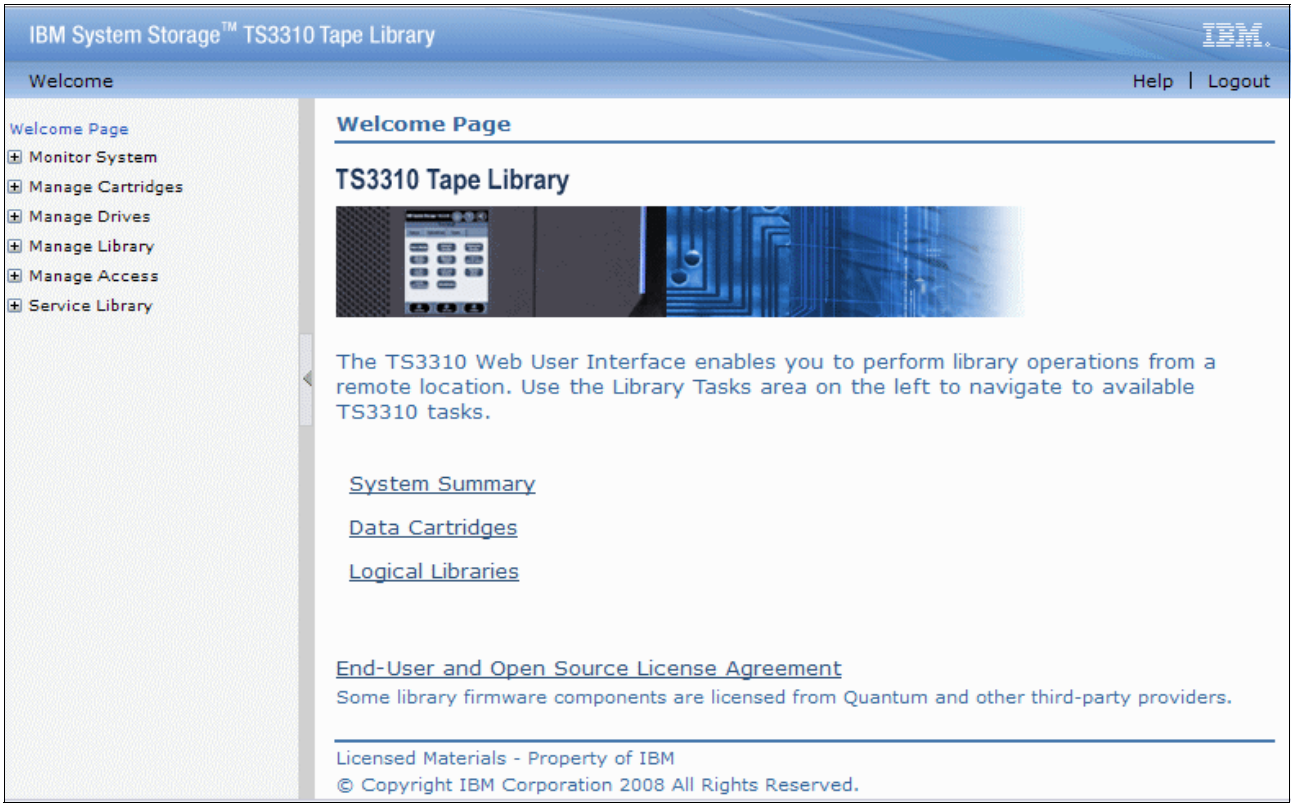


Figure 9-15 TS3310 tape library Welcome Page

Menu options available from the web UI

Figure 9-16 lists the options that are available from the web UI.

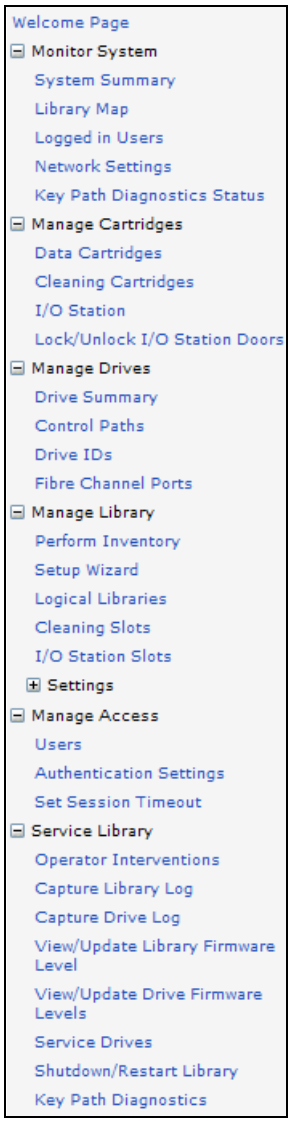


Figure 9-16 Web UI menu

Under Settings, the following important features are available:

- Contact Information
- Date and time
- Email notifications
- Ethernet Speed/Duplex settings
- Feature licenses
- Media Detection
- Network
- Save and restore configuration
- Simple Mail Transfer Protocol (SMTP) (Mail) Configuration
- SNMP Configuration
- SNMP Destinations

Under Service Library, the following important options are available:

- Capture Drive Logs
- Capture Library Logs
- Key Path Diagnostics
- Operator Interventions
- Reset Drive
- Shutdown/Restart Library
- View/Update Drive Firmware Level
- View/Update Library Firmware Level

User privileges

User privilege levels are manually assigned to user accounts that are created within the library. Controlling access to windows and operations within the library preserves the integrity of the library and the data that is stored in the library.

The following types of user privileges are in the library:

- Administrative users are allowed access to the entire physical library and all of its logical libraries. Only one administrator user can be assigned the login name `admin`.
- Superuser has more privileges and can perform more functions than Users, but less than Administrators.
- Users are allowed to operate a logical library, but they cannot perform actions that affect the physical library.

The following user privileges are available:

- A screen saver starts after ten minutes of inactivity on the operator panel. The web UI does not use a screen saver.
- An administrative user can set the session timeout interval to one of the discrete values of 15, 30, 60, 480, or Never from the web UI. From the Operator Panel, it can be set in 1 minute intervals, within the range of 15 - 480 minutes.
- Up to 18 users and one administrative user can be logged in at one time on the web UI. Only one user (administrative or service) can be logged in at one time on the operator panel. One administrative user can disconnect another administrative user.
- Any user can be logged in to only one interface at a time.
- When a service user logs in, all other users and administrative users are logged out and notified that they cannot perform actions on the library. A message is posted that service is logged in and no other users can access the library until after the service user has logged out.

Important: If your library is running firmware version 600G or later, the length for library user and administrator passwords are limited to 6 - 16 alphanumeric characters. If your library is running firmware version below 600G, the length for library user and administrator passwords is limited to 6 - 12 alphanumeric characters.

9.7.3 Command-line interface

The TS3310 tape library CLI (program) can be used to access the TS3310 tape library from a CLI. This program is in addition to the TS3310 tape library Web Specialist User Interface. The TS3310 tape library CLI is oriented to the open system platforms.

All view commands create an output that is comma-separated value (`.csv`) style. The output is directed to the command prompt window by default, but it also can be redirected to a file.

To use the TS3310 tape library CLI, you must satisfy the following requirements:

- The TS3310 tape library must be at a firmware level 587G.GS003 (or higher).
- Java 5.0 or later must be installed.

You can generate the cartridge movement by using the TS3310 tape library CLI, which is generally performed based on the following cartridge location:

- Moving to storage
- Moving to I/O

For more information about the TS3310 tape library CLI, see 12.2.3, “Command-line interface” on page 427, and the TS3310 tape library Command-line Interface website at:

`https://www.ibm.com/support/docview.wss?uid=ssg1S4000981`

9.7.4 Native SMI-S support

The TS3310 tape library conforms to Storage Management Initiative Specification (SMI-S) 1.2 by using an agent that is embedded in the library. SMI-S 1.2 conformance means that the TS3310 tape library adheres to SMI-S Version 1.2 that is defined by the Storage Network Industry Association (SNIA). For more information about SMI-S compliance, see “IBM tape libraries and SMI-S” on page 433.

With the standard management interface, multiple storage management devices (for example, SMI-S compliant tape libraries, disk arrays, and SAN switches) from many vendors all can be managed from a single storage resource management application, such as IBM Tivoli Storage Productivity Center.

In practice, the following types of information are visible:

- Cartridge: A label, the capacity, the type, whether it is a cleaner media, whether it is dual-sided, the location, and a media description.
- Changer: The status, whether media-flip is supported, the worldwide node name (WWNN) or worldwide port name (WWPN), and the firmware version.
- Drive: The status, whether it needs cleaning, the number of mounts, the WWNN or WWPN, the firmware version, and the location.
- I/O Port: The extended state and location.
- Library: The status, number of drives, number of changers, number of cartridges, number of slots, model, vendor, description, owner, contact, firmware version, element manager, lock present, locked state, and security breach state.

In addition, you can start the native management tool (which, in the case of the TS3310 tape library, means the web interface) from the Tivoli Storage Productivity Center.

9.7.5 Support for IBM Tivoli Storage Productivity Center

The IBM Tivoli Storage Productivity Center is a suite of storage infrastructure management tools that can help reduce the complexity of managing storage environments. To work with Tivoli Storage Productivity Center, the TS3310 firmware must have release 300G.GS010 or later installed.

For the TS3310 tape library, the Tivoli Storage Productivity Center Tape Manager works in the following ways:

- It displays the physical entities of the TS3310 tape library, as seen in Figure 9-17 on page 274.
- Alerts are not supported for the TS3310 tape library.
- WWNNs are not reported.
- The TS3310 tape library Common Information Model (CIM) Agent is embedded, and no extra CIM Agent is needed.

The IBM Tivoli Storage Productivity Center Suite offers the following advantages:

- Helps centralize the management of your storage infrastructure from a single interface by using role-based administration and single sign-on.
- Provides a single management application with modular integrated components that are easy to install; provides common services for simple, consistent configuration and consistent operations across host, fabric, and storage systems.
- Manages performance and connectivity from the host file system to the physical disk, including in-depth performance monitoring and analysis of SAN fabric performance.
- Manages the capacity use and availability of storage systems, file systems, and databases.
- Monitors, manages, and controls (zone) SAN fabric components.
- Automates capacity provisioning of file systems.
- Monitors and tracks the performance of SAN-attached SMI-S compliant storage devices.
- Manages advanced replication services (Global Mirror, Metro Mirror, and IBM FlashCopy®) on the disk systems.

With IBM Tivoli Storage Productivity Center, you can perform the following tasks:

- Manage the capacity use of storage systems, file systems, and databases.
- Automate file system capacity provisioning.
- Perform device configuration and management of multiple devices from a single user interface.
- Tune and proactively manage the performance of storage devices on the SAN.
- Manage, monitor, and control your SAN fabric.

Tivoli Storage Productivity Center is a single integrated solution that helps improve the management of storage. It combines the assets, capacity, performance, and operational management that are traditionally offered by separate Storage Resource Management, SAN Management, and Device Management applications into a single platform. For more information about Tivoli Storage Productivity Center, see these resources:

- The IBM Tivoli Storage Productivity Center website at:

  http://www.ibm.com/systems/storage/software/center/index.html
- 12.2, “Management tools and technologies” on page 424.

Figure 9-17 shows an example of IBM Tivoli Storage Productivity Center monitoring a TS3310 tape library.

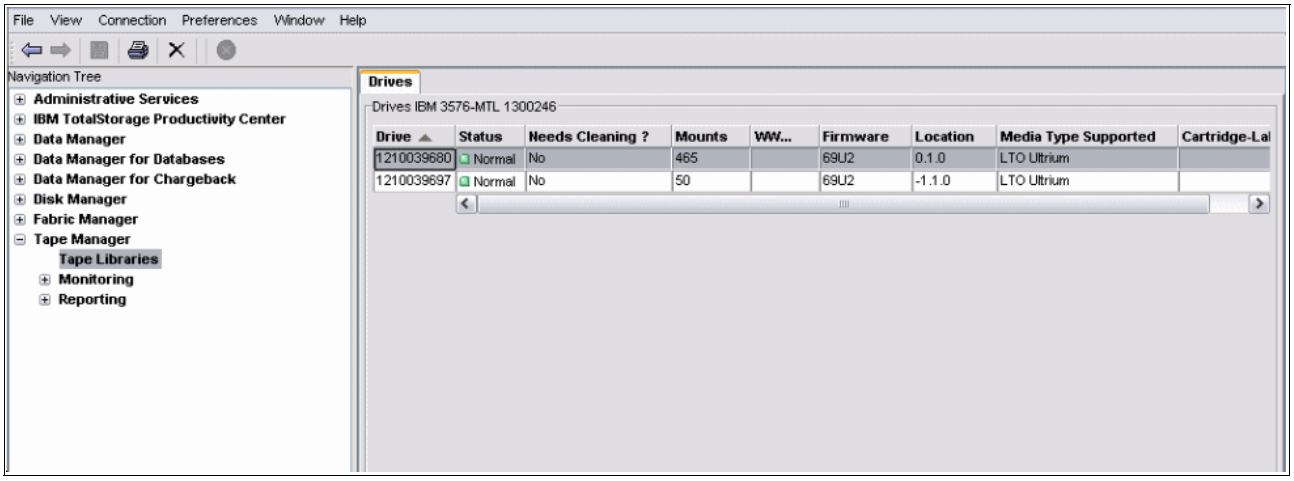


Figure 9-17 IBM Tivoli Storage Productivity Center view of a TS3310 tape library

9.7.6 Advanced Reporting

Advanced Reporting (FC1650) is a licensed key that enables the following functions of the TS3310 tape library:

- Drive Resource Utilization Reporting
- Media Integrity Analysis Reporting

These user-configurable reporting features provide graphical displays for diagnostic and trend analysis data that you can use to evaluate tape drive and media performance and drive use parameters. Advanced Reporting is only available to administrative and service users through the web UI. Data for Advanced Reporting must persist for 12 months, but it is also limited to 1 MB. The persisted data is checksum-protected and persists through a library power loss. The raw data for these reports also can be downloaded and sent by email as a comma-separated values (`.csv`) file through the remote web UI.

Drive Analysis Reporting

The Drive Analysis Reporting function records drive read/write history, which you can use to identify drives or groups of drives that are nearing 100% utilization. It also identifies drive resources that are not fully used. These reports provide the information that is necessary to determine if and when more drives are necessary.

The following data is collected and saved for these reports:

- Drive location (module, row)
- Drive serial number
- Logical library
- Megabytes read
- Megabytes written
- Time and date of mount in Greenwich mean time (GMT)
- Time and date of unmount (in GMT)
- Media motion time (in seconds)
- Media bar code

When you select **Monitor System** → **Advanced Reporting** → **Drive Utilization**, you see the panel that is shown in Figure 9-18. In this example, no data is on the library for the drive utilization reports.

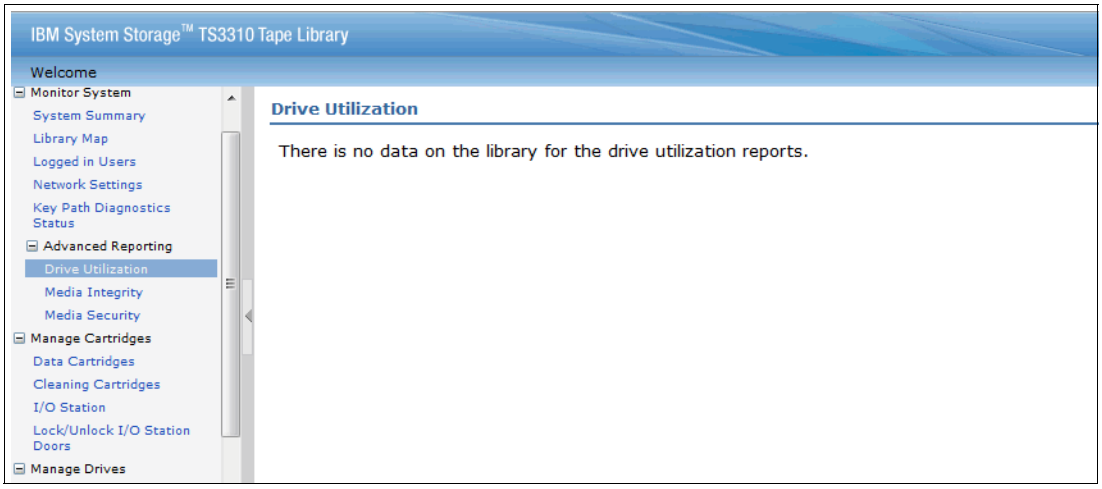


Figure 9-18 TS3310 tape library Advanced Reporting Drive Utilization

Media Integrity Analysis Reporting

The Media Integrity Analysis Reporting function records TapeAlert events to measure and evaluate media and drive performance in the library. The administrator can request and configure various reports to assist in managing the overall reliability and performance of the media and drives.

The following data is collected and saved for these reports:

- Media bar code
- Drive serial number
- TapeAlert value
- Occurrence count of TapeAlert
- Time and date of last TapeAlert occurrence (in GMT)

When you select **Monitor System** → **Advanced Reporting** → **Media Integrity**, you see the panel that is shown in Figure 9-19.

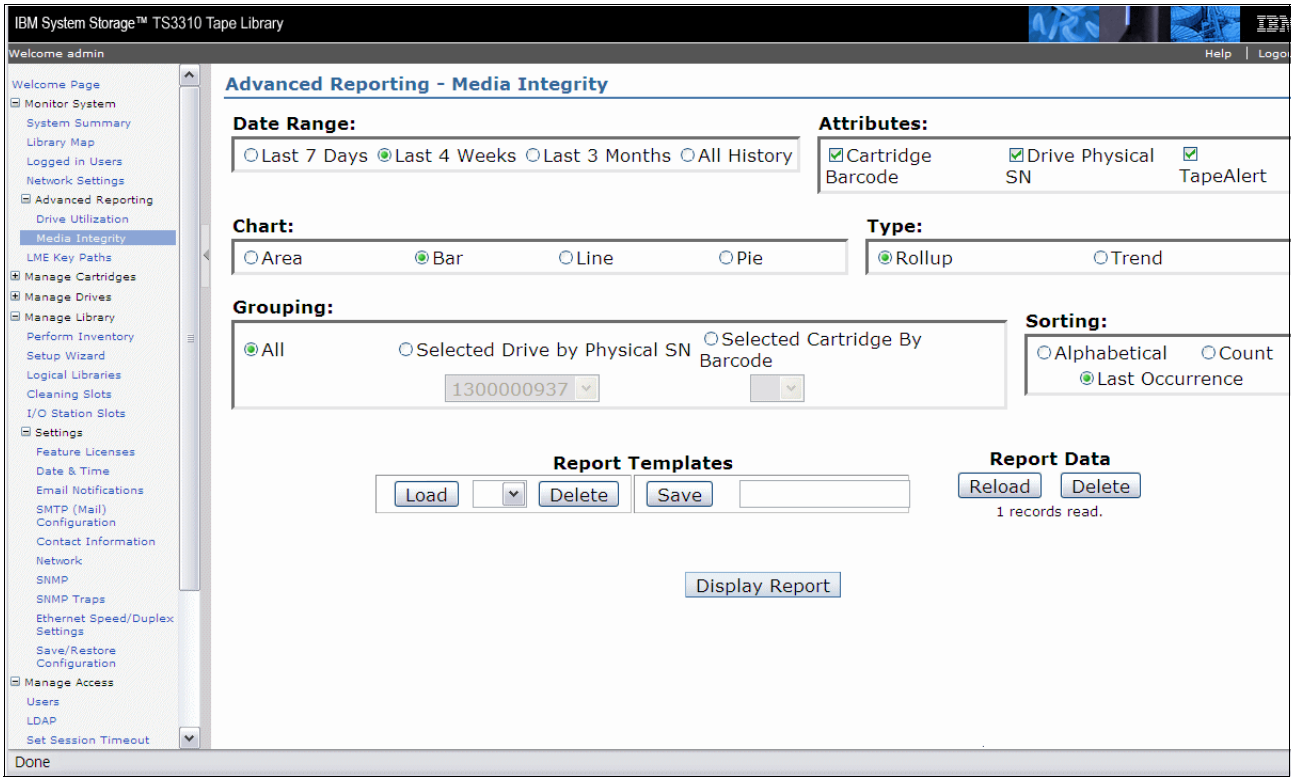


Figure 9-19 TS3310 tape library Advanced Reporting Media Integrity

When you select parameters in the Advanced Reporting Media Integrity panel and click **Display Report**, you see a panel similar to the example that is shown in Figure 9-20.

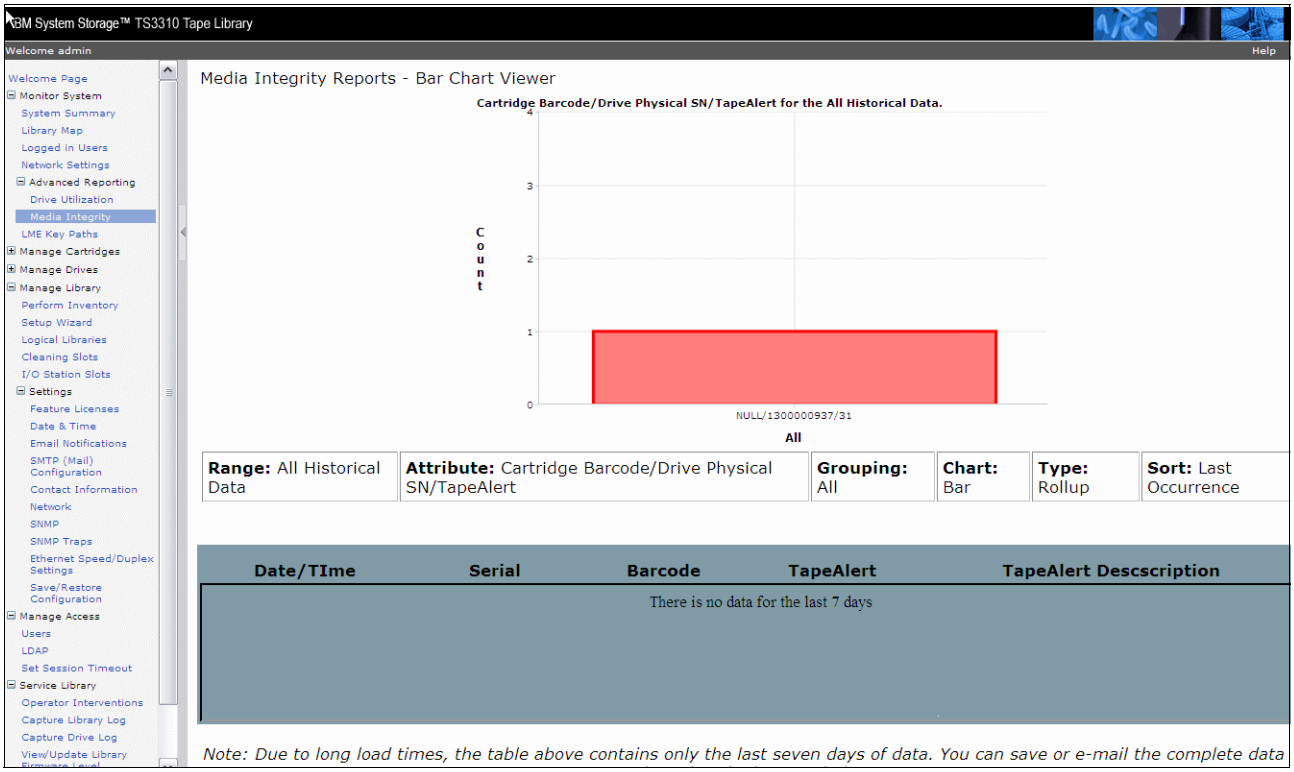


Figure 9-20 Report chart for TS3310 tape library Advanced Reporting Media Integrity

9.7.7 Encryption

The TS3310 tape library supports host AME, SME, and LME for SAS and Fibre Channel drives only. Data encryption is supported with LTO Ultrium 6, Ultrium 5, and Ultrium 4 Data Cartridges only.

The installation of IBM Ultrium 6 tape drive with encryption might require code updates for Power Systems, supported open systems device drivers, or storage management software. For more information about supported software versions and release levels for the Ultrium 6 tape drive and for hardware support information, see the IBM Tape Storage Systems page at this website:

`http://www.ibm.com/storage/tape`

AME is available at no charge. Multiple Backup Applications now support AME, including IBM Tivoli Storage Manager.

SME and LME need FC5900 feature code. FC5900 is a Transparent LTO Encryption feature, which provides a license key to enable SME and LME.

Important: For LTO Ultrium 5 and Ultrium 6, the IBM Security Key Lifecycle Manager v1.0 and later is required for enabling SME and LME.

Before tape encryption is set up on the TS3310 tape library, you must install your Key Manager on a server in your network. A Key Manager is needed when SME or LME is configured. Valid methods for TS3310 tape library encryption are AME, SME, and LME. SME and LME require another license key.

Important: If you have not installed an encryption license key, you cannot choose SME or LME methods. If you attempt to choose either of these methods without an installed encryption key, an error message displays and the encryption method defaults to None.

For more information about how to set up encryption on the TS3310 tape library, see *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477.

Encryption requires the latest device drivers, which are available at this website:

`http://www.ibm.com/support/fixcentral/`

For more information, see 2.2, “Tape encryption overview” on page 67.

Key Path Diagnostics

An Encryption Key Path Diagnostics (KPD) function is provided to assist the Administrative user in the setup, configuration, or troubleshooting of Library Managed Encryption (LME) enabled libraries. This diagnostic function consists of four tests, which you can run sequentially on each IP address of each drive that is enabled for LME.

For more information about how to use the Key Path Diagnostics function on the TS3310 tape library, see *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477.

9.8 Multipath architecture

With a multipath architecture, multiple systems can share the robotics of a library without middleware or a dedicated server (host) acting as a library manager. The library is controlled through the same physical connection as the connection that is used for the tape drives. By using multipath architecture, more control paths and data paths can be configured for any one logical library.

Multipath architecture has the following benefits:

- Eliminates the need for a separate dedicated control path to the library, which removes a single point of failure.
- Allows for Control Path Failover. If one control path is lost, for example, because of a tape drive hardware failure, the library can still operate through a different path without the need for manual intervention.
- Allows for Data Path Failover. For example, if access to a drive by using one HBA is lost, a separate path can be used without the need for manual intervention.
- Allows the library to be partitioned into multiple logical libraries. Each system that is connected to the library (through the tape drives) considers that it has access to an entire library (rather than merely part of a physical library) and is unaware that the robotics are shared.

Multipath architecture is compliant with SCSI and Fibre Channel interfaces.

The library is certified for SAN solutions, such as LAN-free backup.

9.8.1 Using multiple logical libraries for library sharing

Multiple logical libraries are an effective way for the library to simultaneously back up and restore data from heterogeneous applications. For example, the library can be partitioned so that it processes the following commands:

- Commands from Application 1 (about Department X) in Logical Library A.
- Commands from Application 2 (about Department Y) in Logical Library B.
- Commands from Application 3 (about Department Z) in Logical Library C.

In this configuration, the storage slots and drives in each logical library are dedicated to that library and are not shared among other libraries. Commands that are issued by the applications travel to the library through the following unique control paths for data processing:

- Department X is confined to the storage slots and drives in Logical Library A.
- Department Y is confined to the storage slots and drives in Logical Library B.
- Department Z is confined to the storage slots and drives in Logical Library C.

9.8.2 Using multiple control paths

In addition to creating multiple logical libraries, any logical library can be configured to have more than one control path. When more control paths are configured, more library sharing configurations and availability options are made possible. Access to the logical library is on a first-come, first-served basis. Each control path for a logical library can accept commands while the library is in use by another control path. By default, a logical library can communicate with the server only through the first LUN 1-enabled drive that is installed in the partition. Microsoft Windows 2000 Removable Storage Manager and Microsoft Windows Server 2003 Removable Storage Manager do not support multiple control paths within a logical library. You must disable Remote Storage Manager to use this feature.

To add or remove control paths, use the operator panel or the web UI. For a particular logical library, you can enable as many control paths as there are drives in that logical library.

9.8.3 Using multiple control paths for Control Path Failover

Command failures and time outs are costly. You want your library to run smoothly and efficiently. To ensure continued processing, the library offers an optional Control Path Failover feature. By using this feature, the host device driver can resend the command to an alternative control path for the same logical library. With Control Path Failover installed, the alternative control path can include another HBA, SAN, or library control path drive. The device driver initiates error recovery and continues the operation on the alternative control path without interrupting the application. AIX, Linux, Solaris, HP-UX, and Windows hosts are supported for this feature, which can be installed by the client.

Tip: The Path Failover feature includes license keys for activating Control Path Failover and Data Path Failover. Path Failover is a combination of two previous features: Control Path Failover (key entered at the library user interface) and Data Path Failover (key entered at the device driver interface). A single activation key that is entered at the library user interface now activates both features, with one exception. For LTO Ultrium 3 drives with firmware level 73P5 or lower, the device driver interface Data Path Failover key activation is still required.

For more information about how to use the Control Path Failover feature, see *IBM Tape Device Driver Installation and Users Guide,* GC27-2130.

9.8.4 Using multiple data paths for Data Path Failover

Data Path Failover and load balancing exclusively support native Fibre Channel Ultrium 6, Ultrium 5, and Ultrium 4 tape drives in the library by using the IBM device driver for AIX, Linux, Solaris, HP-UX, and Windows. Data Path Failover provides a failover mechanism in the IBM device driver so that multiple redundant paths can be configured in a SAN environment. If a path or component failure occurs, the failover mechanism can automatically provide error recovery to try the current operation again by using an alternative, preconfigured path without stopping the current job in progress. The failover mechanism provides flexibility in SAN configuration, availability, and management.

When a tape drive device is accessed that was configured with alternative paths across multiple host ports, the IBM device driver automatically selects a path through the HBA that has the fewest open tape devices. It then assigns that path to the application. This autonomic self-optimizing capability is called *load balancing*.

The dynamic load balancing support optimizes resources for devices that have physical connections to multiple HBAs in the same machine. The device driver dynamically tracks the use on each HBA as applications open and close devices. It also balances the number of applications that use each HBA in the machine. The dynamic load balancing support can help optimize resources and improve overall performance.

Furthermore, Data Path Failover provides autonomic self-healing capabilities similar to Control Path Failover, with transparent failover to an alternative data path if a failure occurs in the primary host-side path.

9.9 Working with logical libraries

Logical libraries are virtual sections within a library that present the appearance of multiple, separate libraries for the purposes of file management, access by multiple users, or dedication to one or more host applications. By default, the library has one logical library, which includes all of the resources of the library if all of the tape drives in the library have the same type of interface (Fibre or SAS). If not, a separate logical library is created for each of the different drive type interfaces, groups those drives into that logical library, and then distributes the other resources of the library equally.

You can create logical libraries by using one of the following methods:

- Automatically: The library divides the available resources equally among the number of logical libraries that are chosen.
- Manually: An administrative user assigns the number of slots per logical library. You can create logical libraries manually only through the web UI.

Important: When the logical library mode is changed from online to offline, all host application commands in progress at the start of the mode change complete.

Administrative users can create, modify, delete, and control access to all logical libraries (see Figure 9-21). Users can be given access only to certain logical libraries and denied access to others. At a minimum, a logical library consists of one tape drive and one slot. The tape drive or slot cannot be shared with another logical library. (Cleaning cartridges, which can be shared among all logical libraries, are exceptions to the sharing restrictions). I/O station slots and cleaning slots are shared among all logical libraries. Each logical library is specific to a tape drive interface, for example, SAS or Fibre Channel. Mixed media is allowed within logical libraries. For example, a logical library can contain LTO-6 and LTO-5 tape cartridges.

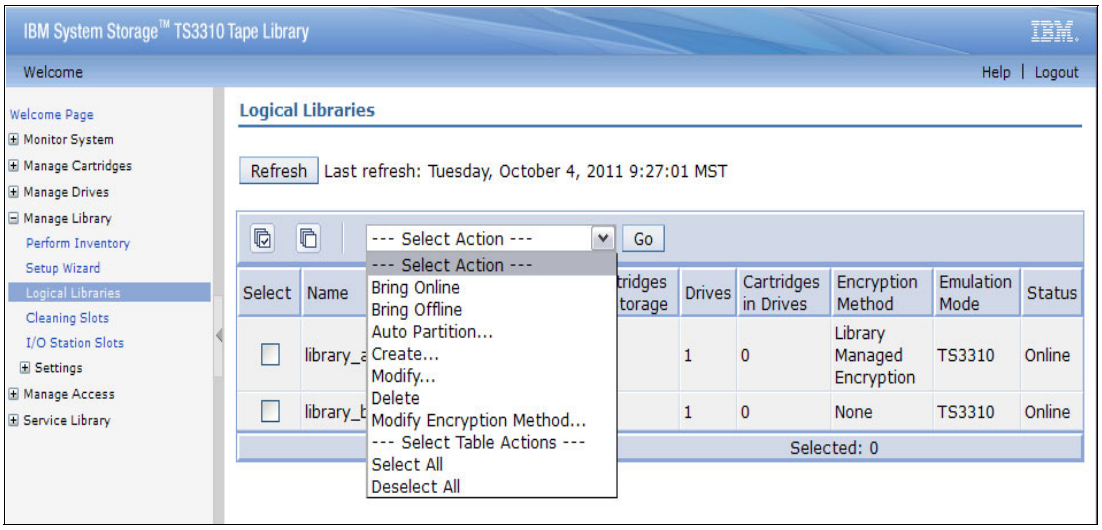


Figure 9-21 TS3310 tape library Logical libraries configuration panel

9.9.1 Automatically creating logical libraries

When a library automatically creates logical libraries, the available resources are divided equally among the number of logical libraries that are created, according to the different drive interface types. Before logical libraries are created, you must first designate the preferred number of cleaning slots and I/O slots (if an expansion module is present). This designation is necessary because the Automatic Create Logical Library function divides all available storage slots among the chosen number of logical libraries.

From the operator panel, all remaining available resources are divided among the number of automatically created logical libraries. Use the web UI to manually create logical libraries, as shown in Figure 9-21.

Tip: On the web UI, you must delete all logical libraries before the Automatic Partition option is used.

9.9.2 Manually creating logical libraries

Every logical library must have at least one drive and one storage slot assigned to it. For example, if the library has two tape drives and 12 slots available, the maximum number of logical libraries that you can create is two. Up to 12 slots can be allocated between the two logical libraries in any configuration.

If the library has only one logical library with all resources assigned to it, that logical library can be deleted to free up resources for reallocating them to a new logical library, or it can be modified to free up resources so that they can be reallocated to the new logical library.

You might need to provide information for the following fields:

- Automatic Drive Cleaning: Enabled by default and requires at least one cleaning cartridge that is labeled as CLN or CLNU as the prefix.
- Emulation Type: Simulates the logical library.
- Logical Library Name: Can be up to a maximum of 12 alphanumeric characters.
- Media Barcode Format: Defaults to the last eight characters.
- Number of Slots: The number of tape cartridge slots that are to be allocated to the new logical library.

9.9.3 Deleting logical libraries

A logical library can be deleted when it is no longer needed. After a logical library is deleted, its resources become unassigned and can be used to create more logical libraries or added to existing logical libraries.

9.9.4 Changing logical library access

An administrative user can control which logical libraries a specified user can access by modifying a user's account. To change logical library access, you must provide the following information:

- Password: A unique string of alphanumeric characters that can be viewed and modified by the administrator.
- Privilege level: The level of library functions to which a user is assigned access.

9.9.5 Changing logical library modes

By default, the library has one logical library enabled. You must change the logical library mode to modify the logical library or library. The following logical library modes are available:

- Online: The normal operating condition for a logical library. In this mode, the robotics are enabled, and all host application commands are processed.
- Offline: The logical library does not process any host application commands. If a logical library is taken offline, the physical library and other logical libraries are not affected.

You can take the physical library or any of its logical libraries online or offline. Certain operations require that the logical library be offline. Administrative users and superusers can take a logical library offline rather than the entire library to minimize the disruption of library operations. Administrative users and superusers must manually change the logical library mode to online or offline from the operator panel or the web UI.

When you are changing logical library mode, keep in mind the following information:

- The Online/Offline button toggles between states.
- If a logical library is in use, the Online/Offline button is disabled.
- Set the button to read Online to take the physical library or a logical library (depending on the current view) to an online state, which is the normal operating condition. In this mode, the robotics are enabled, and all host commands are processed.
- Set the button to read Offline to take the physical library or a logical library (depending on the current view) to an offline state. If only the physical library is taken offline, logical libraries do not process robotics commands, even though they are online. If only a logical library is taken offline, the physical library nor the other logical libraries are affected.

9.10 Supported environments

For a current list of supported server platforms, operating systems, host bus adapters, SCSI adapters, and SAN switches, see the System Storage Interoperation Center (SSIC) page at this website:

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

On the page, under Storage Family, select **IBM System Storage LTO Ultrium Tape**. Then select the product model for the TS3310 tape library and the version.

Date changes: The list of supported environments constantly changes. The supported platforms and operating systems are provided to show the breadth of current support.

9.10.1 Supported server platforms

The TS3310 tape library is supported on the following servers:

- AMD servers
- Hewlett-Packard servers
- IBM System i, iSeries, and AS/400
- IBM Flex Systems
- IBM Power Systems (p6 and newer), IBM System p (p5 or earlier), pSeries, and RS/6000
- IBM System z Linux and zSeries Linux
- IBM System x and Intel technology-based servers
- Oracle SUN servers

Important: Direct attachment of the LTO Fibre tape drive to an IBM System i, iSeries, or AS/400 requires that the LTO Fibre tape drive's Topology Port setting be set to L-Port. Make this configuration change via the library web GUI.

9.10.2 Supported operating systems

The TS3310 tape library is supported on the following operating systems at the minimum levels that are indicated:

- AIX V5.3, or later
- IBM i5/OS V5R4 or later
- HP-UX 11iv2 (11.23), and 11iv3 (11.31)

  HP-UX patches might be required.
- Linux distributions:
  - Red Hat Enterprise Linux Version 4 or 5
  - SUSE Linux Enterprise Server 10 or 11
  - Asianux 2.0 or 3.0
- Microsoft Windows Server 2003 SP2
- Microsoft Windows Server 2008 R2 SP1 and SP2
- Microsoft Windows Server 2012
- Oracle Solaris 9, 10, and 11

9.10.3 Supported storage software

For a current list of host software versions and release levels that support the TS3310 tape library, see the System Storage Interoperation Center (SSIC) page at this website:

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

The following Storage Software products support the TS3310 tape library at the time of writing:

- Arkeia Software: Arkeia
- Atempo: Time Navigator
- BakBone/Quest Software: Netvault
- CommVault Systems: Galaxy/Simpana
- CA: BrightStor ARCserve Backup
- EMC: AlphaStor, Retrospect, Networker
- Front Porch Digital: DIVArchive
- Help/Systems: Robot/SAVE
- HP: OpenView Storage Data Protector 5.1, 5.5, 6.0, 6.1 and 6.2
- IBM: Backup, Recovery and Media Services (BRMS)
- IBM: HPSS
- IBM: LTFS EE, LTFS LE, and LTFS Storage Manager
- IBM: Security Key Lifecycle Manager
- IBM: Tivoli Storage Manager
- IBM: Security Key Lifecycle Manager
- LXI: MMS and TMS/ix
- Microsoft System Center Data Protection Manager 2007/2010
- Oracle: SAM-QFS
- Syncsort: Backup Express
- Symantec: Backup Exec 12.5 and 2010
- Symantec: NetBackup
- Thales Encryption Manager for Storage: TEMS
- Yosemite/Barracuda: Backup

For more information about LTO, see this website and select **Independent Software Vendor (ISV) Matrix for LTO**:

http://www.ibm.com/systems/storage/tape/ts3310/index.html

IBM Tivoli Storage Manager and other offerings provide storage and tape management software for the TS3310 tape library. The Tivoli Storage Manager base Versions 5 and 6 come with support for the TS3310 tape library.

9.11 Specifications

This section describes the physical specifications and the operating environment for the TS3310 tape library.

9.11.1 Timings

The following timings are approximate and are provided as indicative values:

- To perform an inventory of a 5U library: 1 minute
- To perform an inventory of a 14U library: 4 minutes
- To mount a cartridge in a 5U library: 15 seconds
- To mount a cartridge in a 14U library: 18 seconds
- To unmount a cartridge in a 5U library: 30 seconds
- To unmount a cartridge in a 14U library: 35 seconds

9.11.2 Physical specifications

Physical specifications are provided for the L5B module stand-alone and the 14-U library configuration.

Model L5B

A 5-U library configuration has the following physical specifications:

- Width: 443.2 mm (17.45 in.)
- Depth: 801.4 mm (31.55 in.)
- Height: 219.7 mm (8.65 in.)
- Weight: 38.6 kg (85 lbs.)
- Maximum configuration: Two drives and two power supplies

Model L5B plus E9U

A 14-U library configuration has the following physical specifications:

- Width: 443.2 mm (17.45 in.)
- Depth: 801.4 mm (31.55 in.)
- Height: 620.8 mm (24.44 in.)
- Weight: 88.5 kg (195 lbs.)
- Maximum configuration: Six drives and four power supplies

9.11.3 Operating environment

The following operating environments are supported for all library configurations:

- Temperature: 10–38 degrees C (50–110 degrees F)
- Relative Humidity: 20–80 percent
- Maximum Wet Bulb (Caloric Value): 26 degrees C, 79 degrees F
- Electrical Power: 0.2 kVA
- Capacity of Exhaust: 54 cfm for 5U, 148 cfm for 9U
- Caloric Value: 0.68 kBTU/hr.
- Sound Power Level (LwAd): 6.2 Bels idle, 6.7 Bels operating
- Leakage current: 0.75 mA at 212 Vac per power supply

9.12 Feature codes

Table 9-4 lists the model numbers and feature codes that are associated with the TS3310 tape library.

Table 9-4 Machine type, model numbers, and feature codes

Description	Machine	Model	Feature	Comment
TS3310 tape library	3576 3576	L5B E9U	N/A	Base module Expansion module
Library and Drive Code update	N/A	N/A	0500	Library and drive code update by an IBM Service Representative.
Redundant power supply	N/A	N/A	1900	Optional. Each module ships with one PDU and supports two PDUs.
Capacity expansion	N/A	N/A	1640	Optional
Advanced reporting	N/A	N/A	1650	Optional
Path failover	N/A	N/A	1682	Optional
Ethernet Expansion Blade (EEB)	N/A	N/A	3470	Required for expansion modules (E9U) for Ethernet connection between LTO-6 drives and library.
Ethernet cable	N/A	N/A	610x	Ethernet cable for EEB and tape drive connection.
Transparent LTO encryption	N/A	N/A	5900	Required for SME and LME.
Rack mount kit	N/A	N/A	7003	Hardware required to mount a library in a rack.
LTO Ultrium 4 SAS Drive	N/A	N/A	8139	SFF-8088 interface.
LTO-4 Ultrium (4 Gbps) Fibre Channel drive	N/A	N/A	8142	Fibre Channel interface.
LTO-5 Ultrium (8 Gbps) Fibre Channel drive	N/A	N/A	8242	Fibre Channel interface.
LTO-6 Ultrium (8 Gbps) Fibre Channel drive	N/A	N/A	8342	Fibre Channel interface.
Encryption configuration	N/A	N/A	9900	Documentation for encryption.

Table 9-5 lists the SAS feature codes.

Table 9-5 SAS feature codes

Feature Code	Name	Description
5402	2 m (6.6 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406	5.5 m (18 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5500	2 m (6.6 ft.) Mini-SAS/Mini-SAS 1x4 Fan Out Cable	This feature provides a 1 x 4 fanout cable with mini-SAS/mini-SAS connections for connecting the library and the drives.
5502	2 m (6.6 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506	5.5 m (18 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a mini-SAS (SFF-8088) connector on one end and a mini-SAS (SFF-8088) connector on the other end.
8405	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges and can be ordered only when the TS2340 is ordered.

For more information, see the TS3310 tape library page at this website:

`http://www.ibm.com/systems/storage/tape/ts3310/index.html`

9.12.1 Power cords

The following power cord features are available:

- 9800 9-foot (2.8 m) Power Cord, 125 V, 15 A US and Canada
- 9820 9-foot (2.8 m) Power Cord, 250 V, 16 A (AC) France and Germany
- 9821 9-foot (2.8 m) Power Cord, 250 V, 11 A Denmark
- 9825 9-foot (2.8 m) Power Cord, 250 V, 13 A UK and China
- 9827 9-foot (2.8 m) Power Cord, 250 V, 6-16 A Israel
- 9828 9-foot (2.8 m) Power Cord, 255 V, 10 A Switzerland
- 9829 9-foot (2.8 m) Power Cord, 250 V, 16 A South Africa
- 9830 9-foot (2.8 m) Power Cord, 250 V, 10 and 16 A Italy
- 9831 9-foot (2.8 m) Power Cord, 250 V, 10 A Australia
- 9833 9-foot (2.8 m) Power Cord, 250 V, 15 A US and Canada
- 9834 9-foot (2.8 m) Power Cord, 250 V, 10 A Uruguay
- 9835 9-foot (2.8 m) Power Cord, 125 V, 15 A Taiwan
- 9840 9-foot (2.8 m) Power Cord, 250 V, 10 A China (PRC)
- 9841 9-foot (2.8 m) Power Cord, 250 V, 10 A Taiwan
- 9842 9-foot (2.8 m) Power Cord, 125 V, 12 A Japan
- 9843 9-foot (2.8 m) Power Cord, 250 V, 12 A Japan
- 9844 9-foot (2.8 m) Power Cord, 250 V, 12 A Korea
- 9845 9-foot (2.8 m) Power Cord, 250 V, 10 A India
- 9847 9-foot (2.8 m) Power Cord, 250 V, 10 A Brazil

Fibre Channel cables

The Fibre Channel tape drive has an LC connector. A cable is required to connect this connector directly to a system HBA or a switch. The following feature codes are available:

- FC6005: 5 m (16.4 ft.) LC-LC Fibre Channel Cable
- FC6013: 13 m (42.7 ft.) LC-LC Fibre Channel Cable
- FC6025: 25 m (82 ft.) LC-LC Fibre Channel Cable
- FC5096: Interposer SC-LC Fibre

9.13 Publications

The following publications are included with the Model L5B hardware:

- *IBM System Storage TS3310 Tape Library Maintenance Information for IBM Service Personnel,* GA32-0478
- *IBM System Storage TS3310 Tape Library SCSI Reference,* GA32-0476
- *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477
- *IBM Tape Device Drivers Installation and User's Guide,* GC27-2130

10

IBM TS3500 tape library

The IBM TS3500 tape library allows the use of the LTO and Enterprise 3592 drive technologies within the same library. The TS3500 tape library was known and marketed as the IBM TotalStorage 3584 tape library, Machine Type 3584.

The TS3500 tape library provides tape storage solutions for the large, unattended storage requirements for today's midrange and enterprise (z/OS and open systems) environments. This chapter covers only information relating to the TS3500 tape library attachment in an open systems environment. For more information about TS3500 tape library attachment to a System z environment, see *IBM System Storage TS3500 tape library with System z Attachment: A Practical Guide to Enterprise tape drives and TS3500 Tape Automation*, SG24-6789.

Combining reliable, automated tape handling and storage, with reliable, high-performance IBM LTO Ultrium tape and 3592 drives, the TS3500 tape library offers outstanding retrieval performance with typical cartridge move times of less than three seconds.

The TS3500 tape library can be partitioned into multiple logical libraries. This feature makes it an excellent choice for consolidating tape workloads from multiple heterogeneous open systems servers. It also enables support for System z attachment.

The TS3500 tape library provides outstanding reliability and redundancy through the provision of redundant power supplies in each frame, an optional second cartridge accessor, control and Data Path Failover, and dual grippers within each cartridge accessor. Both library and drive firmware can now be upgraded non-disruptively; that is, without interrupting the normal operations of the library.

In physically constrained data center environments, the option to connect multiple library strings to create a shuttle complex greatly increases opportunities for growth, and the maximum cartridge capacity without the need for more tape drives. With the addition of high-density frames, it also greatly increases capacity without requiring more floor space.

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The TS3500 tape library supports tape encryption on the following tape drives: IBM TS1060 (3588-F6A) tape drive, TS1050 (3588-F5A) tape drive, TS1040 (3588-F4A) tape drive, and IBM 3592 Model E tape drives. The IBM 3592 Model E tape drives include the TS1150, TS1140, TS1130, and TS1120. All three encryption methods are supported: application-managed encryption (AME), system-managed encryption (SME), and library-managed encryption (LME).

This chapter includes the following sections:

- Product description
- Library components
- Tape Library Specialist Management Interface
- Performance
- Upgrades and optional features
- Advanced Library Management System
- Host platforms and device drivers
- Storage applications
- Specifications

10.1 Product description

The TS3500 tape library (Machine Type 3584) is a modular tape library that consists of frames that house tape drives and cartridge storage slots. An individual library, or *library string*, consists of a single base frame and up to 15 expansion frames. This provides the ability to match system capacity requirements.

Table 10-1 lists the supported combinations of frames, tape drives, and their capacities.

Table 10-1 TS3500 tape library capacities

Models	Drives in frames	Maximum cartridges	Maximum capacity without compression
L52, D52, L53, and D53	Ultrium tape drives	6887 L53+15XD53	17217 TB
L32 and D32	Ultrium tape drives	6881 L32+15XD32	17202 TB
L22, D22, L23, and D23	3592 tape drives	6260 L23+15XD23	62600 TB (TS 1150) 25040 TB (TS1140) 6260 TB (TS1130) 4382 TB (TS1120) 1878 TB (J1A)
L22, L23 and S24 High capacity frame.	3592 tape drives	15110 (3592 cartridge)[a]	151100 TB (TS1150) 60440 TB (TS1140) 15110 TB (TS1130) 10577 TB (TS1120) 4533 TB (J1A)
L32, L52, L53 and S54	Ultrium tape drives	20087 (LTO cartridge)[b]	50217 TB

a. Reserve 1% of the slots per S24 frame for sufficient shuffle locations.
b. Reserve 1% of the slots per S54 frame for sufficient shuffle locations.

The extensive granularity of the TS3500 tape library configurations, its features, and its capacities match various client requirements.

The TS3500 tape library is an excellent choice for the following situations:

- Rapid growth in online storage requirements is being experienced.
- Tape libraries with software for automatic backup, archive, or fast-access tape operation are being considered to accommodate growth and reduce manual operations.
- IBM LTO Ultrium format tape is the existing standard drive or there is a need to use enterprise tape drives.
- An IBM tape solution requiring large cartridge capacity and fast data streaming transfer capability is being investigated.
- There are high-availability and reliability requirements.

In Figure 10-1, the left side shows the maximum configuration with 16 frames, and the right side shows the minimum configuration of a TS3500 tape library with a single L Frame. A maximum of 18 frames can be present if the High Availability (HA1) feature were installed because this configuration includes a left and right service bay for concurrent accessor maintenance.



Figure 10-1 Maximum and minimum TS3500 tape library configurations

A total of 13 frames are supported in the current TS3500 tape library range. Each frame is identified by a three-character model number (L32, D32, L22, D22, L52, D52, L23, D23, D53, L53, S24, S54, and HA1), which describes the nature of the frame. Libraries are built of the following modules:

- Every library requires a base frame (model L*xx*) to which optional expansion frames (model D*xx or* model *Sxx*) can be added. Only one base frame is permitted in each library configuration.
- Base and Expansion frames that support either of the following types:
  - LTO-1, 2, 3, 4, 5, and 6 tape drives (Model *x*53, x52, and x32 frames)
  - IBM 3592 J1A, TS1120, TS1130, TS1140, and TS1150 (Model *x*23 and x22 frames)
- An optional second accessor is made available through the addition of the Model HA1 frames.

Model Lxx and Dxx frames can be intermixed with each other and installed frame models. The minimum requirement is that there is one base frame in each library. The S24 can be attached to the tape library that has 3592 drives installed, and the S54 can be attached to the tape library that has LTO drives installed. L22 and D22 frames can be upgraded to the *x*23 frames, and L52 and D52 frames can be upgraded to the *x*53 frames. This provides investment protection and considerable flexibility in configuration and expansion.

Requirement: FC1700 and FC1701 are required when the library frame is not an L53, L23 or D53, D23 model frame. These are required for TS1060 (3588-F6A), TS1050 (3588-F5A), TS1150, TS1140 tape drive, support for SC1 feature, and for any library with a capacity of more than 6887 storage slots. The feature codes provide the enhanced node cards that are required for the minimum version and level of firmware. The Fix Central website provides the latest level of code that is required for these features.

The following frame models are available:

- The TS3500 tape library Model L53 is a base frame that can be installed on its own or in combination with expansion frames. It can host up to 12 Ultrium tape drives and up to 287 IBM Ultrium Tape Cartridges.[1]
- The TS3500 tape library Model D53 is an expansion frame that can be used to provide an additional 12 Ultrium tape drives and a maximum of up to 440 storage slots (depending on the number of tape drives installed)[1]. Up to 15 expansion frames can be installed with a base frame.
- The TS3500 tape library Model L23 is a base frame that can be installed on its own or in combination with expansion frames. It can host up to 12 IBM 3592 tape drives and a maximum of up to 260 storage slots[1].
- The TS3500 tape library Model D23 is an expansion frame that can be used to provide an additional 12 IBM 3592 Model E tape drives. It can also provide a maximum of up to 400 storage slots[1]. Up to 15 expansion frames can be installed with a base frame.
- The TS3500 tape library Model S24 is a driveless, high-density, storage-only expansion frame for up to 1000 3592 tape cartridges. Up to 15 expansion frames can be installed with a base frame. Advanced Library Management System (ALMS) is required for any library with a Model S24 Frame. This frame can optionally be configured as Service Bay B.
- The TS3500 tape library Model S54 is a driveless, high-density, storage-only expansion frame for up to 1320 Ultrium (Linear Tape-Open (LTO)) tape cartridges. Up to 15 expansion frames can be installed with a base frame. ALMS is required for any library with a Model S54 Frame. This frame optionally can be configured as Service Bay B.
- The IBM 3584 tape library Model HA1 is the high availability feature, which provides a second redundant accessor, and service bay features on the TS3500 tape library. This feature provides for the installation of the second library accessor that operates simultaneously with the first accessor and service mount requests in the TS3500 tape library. This feature configures two other frames, service bays, Service Bay A, and Service Bay B.

  Important: The HA1 comes standard with service bay A and the last active frame becomes service bay B. If the user requires to keep the current capacity, a storage frame can be ordered and installed as the storage bay B. This frame can be any storage frame except a Lxx or HA1 frame.

In addition to the D-Frames, a 4 I/O station door is available on newly purchased D23 or D53 frames. A 4 I/O station door has four, 16 slot I/O stations for a total of 64 more I/O slots.

A maximum of three 4 I/O station doors is allowed per TS3500 tape library. This maximum configuration results in a total of 14 I/O stations. All 4 I/O station doors must be the same type (LTO or 3952) and no intermix is allowed. Feature Code (FC) 1451 must be ordered as a prerequisite when a 4 I/O station door is ordered. The following feature codes are available:

[1] The number of storage slots depends on the number of drives and I/O slots that are installed in these frames. The figure that is shown is the maximum number of slots.

- FC1655: 64 Additional I/O Slots - LTO
- FC1656: 64 Additional I/O Slots - 3592

Important: In the TS3500 tape library, place only LTO Ultrium tape cartridges into Ultrium frames with black, Ultrium-supported I/O slots; place only 3592 tape cartridges into 3592 frames with gray-supported I/O slots.

10.1.1 TS3500 tape library frames for IBM LTO Ultrium Fibre Channel drives

The TS3500 tape library Models L53 and D53 integrate the Ultrium 3 TS1030 and Ultrium 4 TS1040 (4 Gbps Fibre Channel FC), TS1050 Ultrium 5 and TS1060 Ultrium 6 (8 Gbps dual-port FC) tape drives. The TS1060 (3588-F5A) tape drives are now supported in the TS3500 tape library at Licensed Internal Code level C070 or later. The Model L53 Frame includes an enhanced Frame Control Assembly with two power supplies (for redundancy), an optimized dual-gripper cartridge accessor, on-demand storage slot capacity, and 16-slot I/O stations. The Model D53 Frame can be attached to any frame models.

TS3500 tape library Model L53

The L53 can be installed on its own as a complete library enclosure, as shown in Figure 10-2 on page 294, or it can have up to 15 expansion frames attached to it. This frame provides the major library components for the whole library, whether it has single or multiple frames. It also provides cartridge storage capacity for LTO media and can be equipped with IBM Ultrium 1, Ultrium 2, Ultrium 3, Ultrium 4, Ultrium 5, and Ultrium 6 tape drives. The expansion frames must be added to the right of the L53 frame.

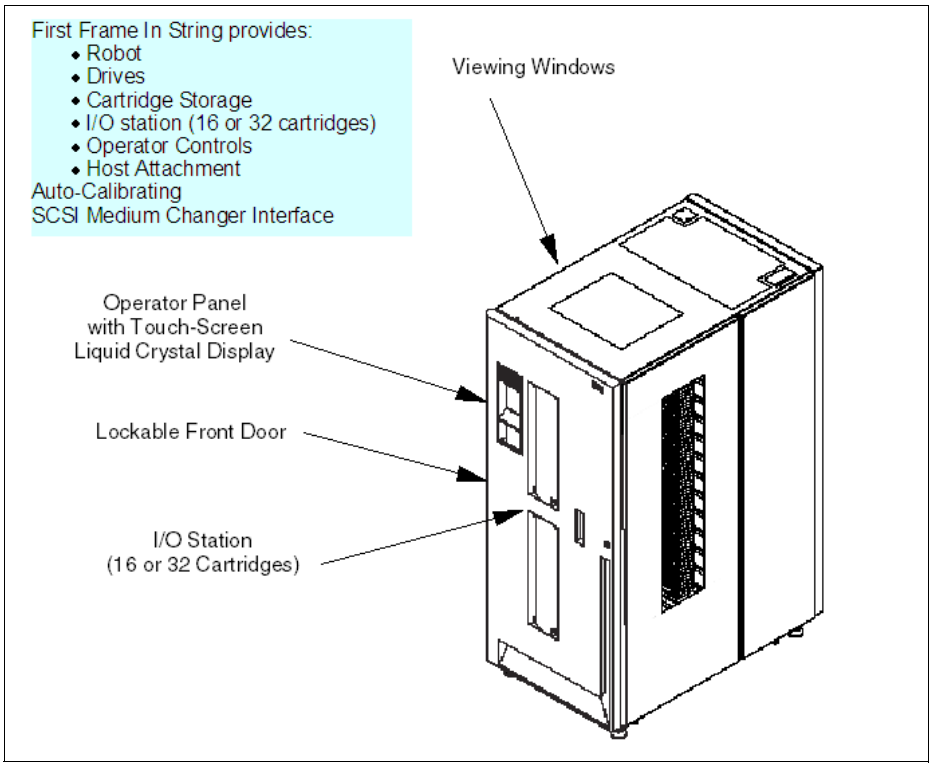


Figure 10-2 TS3500 tape library L53 base frame view from front left

The number of LTO cartridge storage slots ranges from 64 - 287. With the minimum configuration, 64 slots available for use, but the maximum of 287 slots is already physically installed. More slots can be added by enabling them through a license key.

The Intermediate Capacity feature (FC1643) gives a maximum total amount of usable cartridge slots of 129. This feature is required to add a Full Capacity feature (FC1644), which gives the maximum capacity of 287 cartridge slots. The full capacity feature in turn is required to add an I/O slots feature (FC1658 for LTO drives or FC1659 for 3592 drives) or to attach an optional expansion frame. This feature gives a maximum data capacity for the L53 of 717 TB native (up to 1792 TB with 2.5:1 data compression ratio).

Up to 12 IBM Ultrium drives can be installed. All generations of IBM Ultrium LTO tape drives can be installed in the same frame. As more than four drives are added or the other I/O station is installed, there is an incremental reduction in storage slots (see Table 10-2 on page 295). It is also possible to install the LTO FC Drive Mounting Kit (FC1514) in advance to simplify future tape drive installation, but it also reduces the number of available slots.

Table 10-2 L53 frame capacity

Type of Capacity On Demand expansion feature	Quantity of tape drives + drive mounting kits	Quantity of I/O slots	Quantity of storage slots
Entry	0–12	16	64
Intermediate	0–12	16	129
Full	0–4	16	287
Full	5–8	16	273
Full	9–12	16	261
Full	0–4	32	245
Full	5–8	32	231
Full	9–12	32	219

Each TS3500 tape library Model L53 has a standard 16-slot LTO cartridge I/O station for importing or exporting cartridges from the library without requiring reinventory or interruption of library operations. Optional features can provide 16 more I/O slots for LTO (FC1658) or 3592 media (FC1659). The lockable library door can be opened for bulk-loading IBM LTO Ultrium tape cartridges. Reinventory of the cartridges is done in fewer than 60 seconds per frame each time that the library door is closed. A bar code reader that is mounted on the autochanger scans the cartridge labels at less than one minute per frame. A door lock is included to restrict physical access to cartridges in the library. A door open sensor is equipped to prevent accessor movement while the door is open.

TS3500 tape library Model D53

The D53 frame, as shown in Figure 10-3 on page 296, has the same footprint as the model L53. The D53 cannot be installed on its own. It must be connected to a library with a base frame and optionally multiple expansion frames. Up to 16 frames can be connected, as shown in Figure 10-1 on page 292.

If one or more tape drives are installed in the D53, the Enhanced Frame Control Assembly Feature (FC1451) is required with the LTO Fibre Drive Mounting Kit (FC1514). This feature provides the hardware and firmware that is required to support IBM LTO Ultrium drives within the D53 and also provides a redundant AC line feed for the L frame accessor. The Frame Control Assembly Feature also is required if the LTO Fibre Drive Mounting Kit (FC1514) is installed.

D53 frames can be easily configured according to future requirements. By installing the Enhanced Frame Control Assembly (FC1451), the D53 frame is ready to host LTO drives. The

LTO Fibre Drive Mounting Kit (FC1514) prepares the drive slots for hosting an LTO drive. This enables LTO drives to be installed or moved without any other hardware changes.

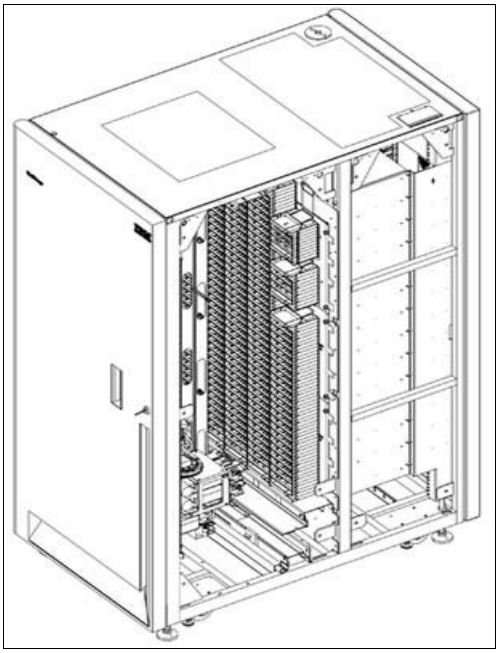


Figure 10-3 TS3500 tape library Model D53 viewed from the right

With the installation of drives and Drive Mounting Kits, the storage slot capacity is reduced, as shown in Table 10-3.

Table 10-3 D53 frame capacity

Quantity of tape drives + drive mounting kit	Quantity of slots in frame
0	440
1–4	422
5–8	408
9–12	396

A fully configured TS3500 tape library with one L53 frame and 15 D53 frames supports up to 192 drives. An L53 base frame and 15 D53 expansion frames with a minimal drive configuration provides a maximum capacity of 6887 storage slots with a total capacity of 17217 TB without compression.

Important: If the L frame is not an L22 or L23, the first D frame of a mixed media library has one less storage slot to accommodate a diagnostic cartridge.

The base L23 or L53 is always on the left, and as many as 15 other D53 and D23 expansion frames can be added to the right side. During the installation of other D53 frames, the x-rail of the L frame is extended where the accessor is so that the accessor can move through the newly installed frame.

If a D53 is added to an installed L32 or D32 frame, FC1610 is required because the D53 is a shorter frame. This feature includes a short rear side cover for the Model D32/L32 frame and the Model D23/D53 front and rear side covers.

Another 16-slot I/O station for LTO media must be ordered through FC1658 if a D53 expansion frame is attached to an L23 base frame.

Up to three other 4 I/O station doors can be installed in the TS3500 tape library. FC1451 is a prerequisite when installing a 4 I/O station door. Figure 10-4 shows the 4 I/O station D-Frame. An LED status panel is in the upper-right corner. The LEDs represent the number of cartridges per I/O station and if the I/O station is locked. The I/O door has a total of 64 slots (16 slots per I/O station).

The 4 I/O station door reduces the frame storage slot capacity by 160 for a model D23 and by 176 for a model D53. The I/O stations increase the maximum library I/O station slots from 32 to 224 because of a maximum of three D23 or D53 I/O frames in the 16-frame library. The D23 and D53 models are compatible with existing models L22, L32, L52, D22, D32, and D52.

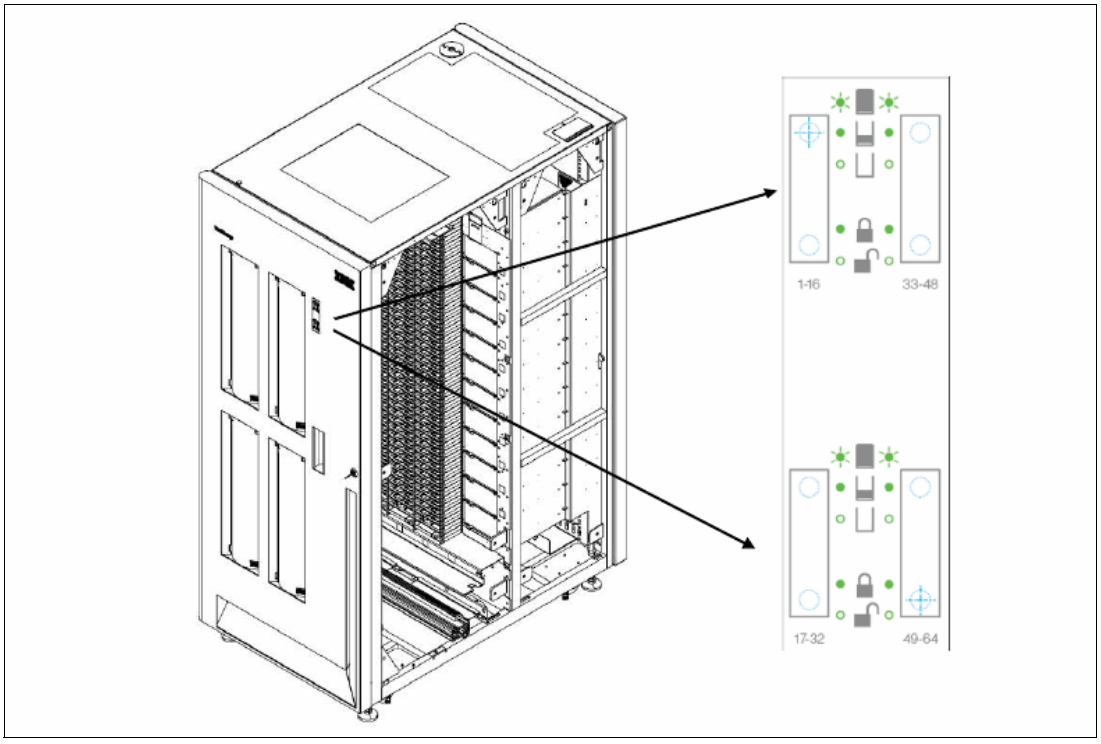


Figure 10-4 A 4 I/O station D-Frame

10.1.2 TS3500 tape library frames L23 and D23

The Model L23 and D23 frames integrate the TS1150 and TS1140 tape drive with an 8 Gbps dual-ported switched fabric Fibre Channel attachment, the TS1130 tape drive and TS1120 Tape Drive, with a 4 Gbps dual-ported switched fabric Fibre Channel attachment, and the IBM 3592-J1A tape drive. The TS3500 tape library Model L23 and D23 frames can be attached to LTO Frames. Therefore, IBM 3592 models E tape drives and LTO tape drives can be intermixed within the same TS3500 tape library.

The IBM 3592 models E tape drives that are used in the TS3500 tape library models L23 and D23 are for automation and use a tape cartridge with a form factor similar to the IBM 3590 tape cartridges. The 3592 tape drives have dual-ported 4 or 8 Gbps Fibre Channel interfaces. The TS1120 tape drive has a native data rate of up to 100 MBps, the TS1130 tape drive has a native data rate of up to 160 MBps, the TS1150 tape drive has a native data rate of up to 360 MBps, and the TS1140 tape drive has a native data rate of up to 250 MBps. The 3592

tape drives provide high levels of performance, functionality, and cartridge capacity supporting the 3592 tape format, including Write Once Read Many (WORM) media support.

IBM TS3500 tape library Model L23 Frame

The TS3500 tape library Model L23 Frame provides cartridge slots for 3592 media and support for up to 12 IBM 3592 tape drives with an incremental reduction of storage slots beyond four drives or with more I/O slots. This model has the same footprint as the model L53. The L23 can be installed on its own as a complete library enclosure, or up to 15 Model D23 or D53 frames can be attached to it. The library capacity and number of drives can be expanded to meet changing needs.

The L23 frame provides the major library components for the whole library, regardless of whether it has single or multiple frames. The expansion frames must be added to the right of the L53 frame.

The number of 3592 cartridge storage slots ranges from 58 to 260. The minimum configuration provides 58 slots that are available for use, although all 260 slots already are installed. To enable the other slots for use (up to the total of 260), obtain another license key by ordering one of the following Capacity-on-Demand features:

- The Intermediate Capacity feature (FC1643) gives a total number of 117 usable cartridge slots. This feature is required to add a Full Capacity feature (FC1644), which gives the capacity of 260 cartridge slots.
- The Full Capacity feature (FC1644) is required to add an I/O slots feature (FC1658 or FC1659) or to attach the optional expansion frame models D23 or D53.

Up to 12 IBM 3592 tape drives can be installed. Adding more than four drives or drive mounting kits, or installing the other I/O station reduces the number of storage slots that are available for use (see Table 10-4). The 3592 FC Drive Mounting Kit (FC1513 or FC1515) for 3592 tape drives can be installed in advance, which simplifies future tape drive installation. This kit reduces the storage slots to the appropriate number and provides the power supply and necessary cables for installing a TS1150, TS1140, TS1130, TS1102 or 3592 J1A tape drive.

Table 10-4 L23 frame capacity

Type of Capacity-on-Demand expansion feature	Quantity of tape drives + drive mounting kits	Quantity of I/O slots	Quantity of storage slots
Entry	0–12	16	58
Intermediate	0–12	16	117
Full	0–4	16	260
Full	5–8	16	248
Full	9–12	16	237
Full	0–4	32	222
Full	5–8	32	210
Full	9–12	32	199

Each L23 has a standard 16-slot 3592 cartridge I/O station for importing or exporting cartridges from the library without requiring reinventory or interruption of library operations. Optional features can provide 16 more I/O slots for LTO media. The lockable library door can be opened for bulk-loading cartridges. Reinventory of the cartridges is done in fewer than 60 seconds per frame each time that the library door is closed. A bar code reader that is

mounted on the cartridge accessor scans the cartridge labels in less than one minute per frame. A door lock is included to restrict physical access to cartridges in the library, and a door open sensor is equipped to prevent accessor movement while the door is open.

IBM TS3500 tape library Model D23 Frame

The Model D23 frame has the same footprint as the Model L23. The Model D23 cannot be installed on its own. It must be connected to a base frame and optionally other expansion frames. Up to 16 frames can be connected.

If one or more tape drives are installed in the D23, the Enhanced Frame Control Assembly Feature also is required (FC1451). This feature provides the hardware and firmware that is required to support IBM 3592 drives within the D23 and provides a redundant line feed for the L23 or L53 accessor.

D23 frames easily can be configured according to future requirements. By installing the Enhanced Frame Control Assembly (FC1451), the D23 frame is ready to host 3592-J1A, TS1120, TS1130, TS1140, or TS1150 tape drives. The 3592 Fibre Channel Drive Mounting Kit (FC1513 or FC1515) prepares the drive slots for hosting a 3592 Model E tape drive. With this feature, 3592 drives can be installed or moved without any other hardware changes.

With the installation of drives or drive mounting kits, the storage slot capacity is reduced, as shown in Table 10-5.

Table 10-5 D23 frame capacity

Quantity of tape drives + drive mounting kit	Quantity of slots in frame
0	400
1 - 4	383
5 - 8	371
9 -12	360

A fully configured TS3500 tape library with one L23 frame and 15 D23 frames supports up to 192 drives. An L23 base frame and 15 D23 expansion frames with a minimal drive configuration provide a maximum capacity of 6260 storage slots, with a total capacity of 62600 TB without compression by using the TS1150 tape drive.

The base frame (model L*xx*) is always on the left and as many as 15 other expansion frames (model D*xx or Sxx*) can be added to the right side. During the installation of more D23 or S24 frames, the x-rail of the L frame is extended where the accessor is, so that the accessor can move through the newly installed frame.

If a D23 or S24 is added to an installed L32 or D32 frame, FC1610 is required because the D23 or S24 is a shorter frame. This feature includes a short rear-side cover for the Model D32/L32 Frame and the Model D23/D53 front and rear side covers.

If a D23 or S24 frame is attached to an L53 frame, the First Expansion Frame Attachment Feature (FC9002) for the L53 must be specified. Subsequent expansion requires the Additional Expansion Frame Attachment feature (FC9003).

More 16-slot I/O stations for 3592 media must be ordered by using FC1659 if a D23 or S24 frame is attached to an L53.

Feature code 1656, a 4 I/O station door, is available on newly purchased D23 frames. One 4 I/O station door has four 16 slot I/O stations for a total of 64 other I/O storage slots. Feature Code (FC) 1451 must be ordered as a prerequisite when a 4 I/O station door is ordered.

Important: If the L frame is not an L32, L52, or L53, the first D frame of a mixed media library has one less storage slot to accommodate a diagnostic cartridge.

10.1.3 TS3500 tape library storage only frames S24 and S54

IBM TS3500 storage-only frame includes the Model S24 Frame and the Model S54 Frame. The TS3500 tape library Model S24 and S54 frames are high density (HD) version 1 storage only expansion frames compatible with existing TS3500 tape libraries and frames.

ALMS is required for S*xx* storage-only frame support. For more information, see 10.6, “Advanced Library Management System” on page 346.

The TS3500 tape library Model S24 expansion frame is for 3592 data cartridges. Up to 15 Model S24 expansion frames can be added to the TS3500 Model L22 or L23 base frame to increase 3592 cartridge storage. Each Model S24 Frame supports up to 1000 IBM 3592 cartridge slots.

The TS3500 tape library Model S54 expansion frame is for LTO data cartridges. Up to 15 Model S54 expansion frames can be added to the TS3500 tape library Model L32, L52, or L53 base frame to increase LTO cartridge storage. Each Model S54 Frame supports up to 1320 LTO cartridge slots.

High-density technology

The depth of a cartridge location in an HD slot is known as the *tier*. The cartridge that is immediately accessible in the HD slot is a tier 1 cartridge. Behind that tier is tier 2, then tier 3, and so on. The maximum tier in an LTO HD slot is tier 5. The maximum tier in a 3592 HD slot is tier 4 because the 3592 cartridge is slightly longer than the LTO cartridge. The single HD slots on the door side of HD frames and in non-HD frames are referred to as *tier 0 slots*.

Figure 10-5 shows an exterior view of S24 frame. The S54 frame has a similar exterior view. The difference is that S54 has tier 5 slots inside for LTO cartridges.

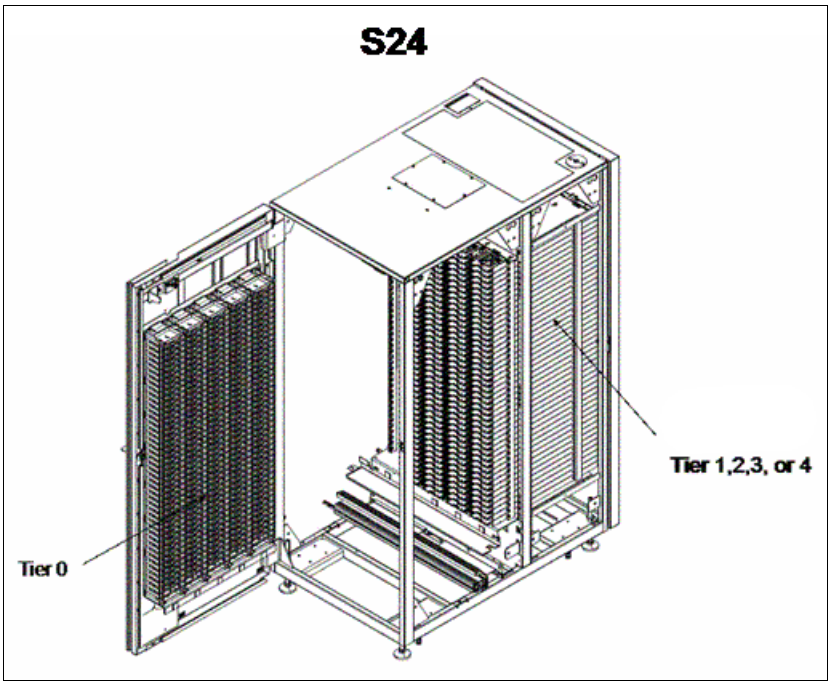


Figure 10-5 S24 frame

Figure 10-6 shows the side view of the HD frame. The S24 frame supports up to 5 tiers (Tier 0 to Tier 4) with up to 200 IBM 3592 cartridge slots for each tier. The S54 frame supports up to 6 tiers (Tier 0 to Tier 5) with up to 220 IBM LTO cartridge slots for each tier.

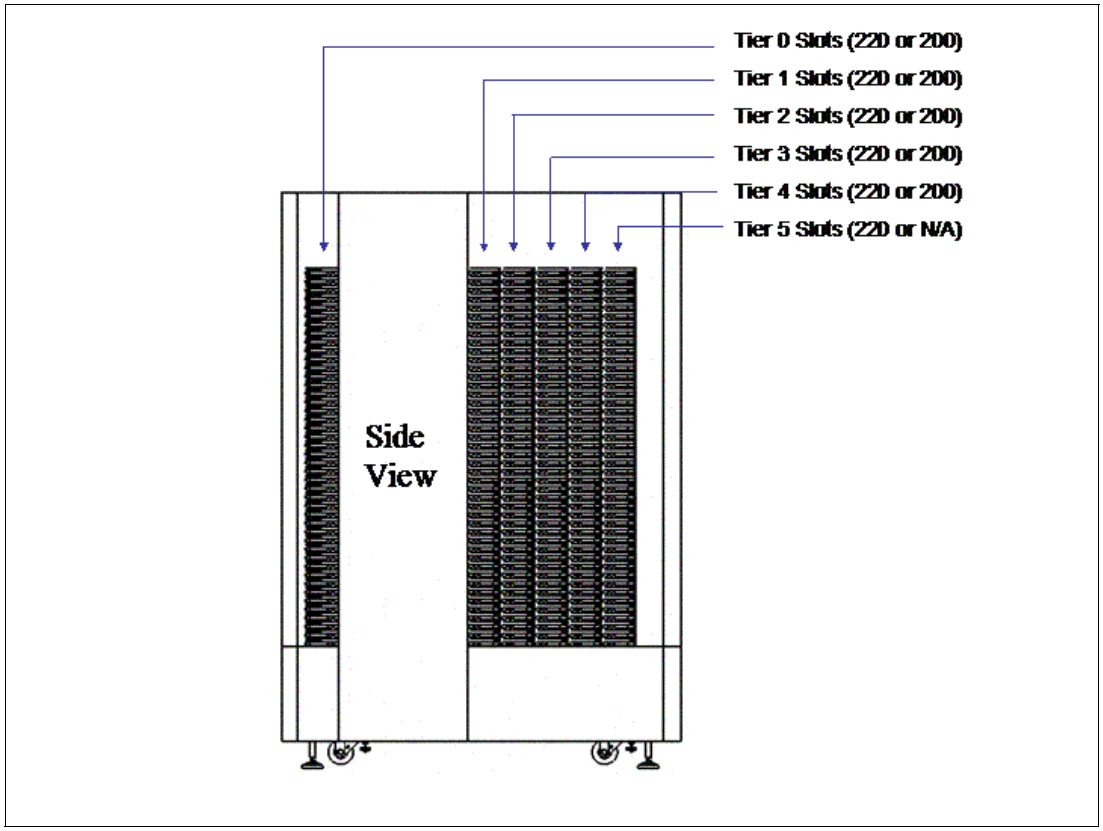


Figure 10-6 S24 frame side view

Library configurations supported by HD frames

The HD frames support the following library configurations:

- Mixed media, LTO only, and 3592 only media in non-HA libraries
- Active frames in HA LTO only or 3592 only libraries
- Service bay B in HA LTO only or 3592 only libraries
- TS3500 tape library Shuttle Complex Model SC1 connection

The HD frames do not provide support for the following library configurations:

- Active frames in a HA mixed media library
- Service bay B in a HA mixed media library

Capacity on Demand for HD frame

HD frames support HD Capacity-on-Demand, and slot capacity can be added non-disruptively to S*x*4 frames. FC1645 provides on-demand activation of another 400 slots of capacity (Tiers 3 and 4) for Model S24. FC1646 provides on-demand activation of another 660 slots of capacity (Tiers 3, 4, and 5) for Model S54.

To support more than 6887 slots in an xx2 library with an Sx4 frame, all node cards in the library must be enhanced node cards. This requires an xx3 model conversion or the Enhanced Node Card(s) feature (FC 1700 or 1701).

HD frame concept

Accessing any cartridge in Tier 2 or greater requires a shuffle operation. A *shuffle* is the process of moving cartridges in lower tiers into the gripper or other available slots to access cartridges in higher tiers (Tiers 2 or greater). Tier 2 cartridges only require a swap by using the dual grippers (assuming both grippers are usable).

To reduce the occurrence of shuffle operations and to take advantage of the typical repeated accesses of cartridges, the role of a cartridge cache is given to all single deep (Tier 0) slots in a library that contains HD slots.

Even with the concept of a cartridge cache, cartridges still need to be moved into HD slots (for example, cartridge insertions and cartridge cache destage operations). To improve the predictability of the performance penalty of shuffle operations, the library firmware load balances the placement across all HD slots in the library string. Furthermore, the library monitors for a specific fullness threshold at which predictability of performance cannot be maintained. It provides sufficient warnings to the user of this degraded state, for example, UI, Simple Network Management Protocol (SNMP), or TapeAlert. The objective is for this threshold to be no less than 98% of the total physical capacity.

Because of the predictable tiered performance impact of cartridges in HD slots, the concept of a cartridge cache is introduced with the HD frame. The cartridge cache is all single HD slots in the library, whether door-side or drive-side in any frame. The cache is managed with a Least Recently Used (LRU) algorithm. The library firmware records the date and time of the most recent use (virtual or physical move) for each cartridge. Nominally (but with some exceptions), a cartridge that is unmounted from a drive is moved to a cartridge cache slot. When an empty cache slot is not available, the firmware compares the use data and performs an LRU cache destage move (from a cache slot to an HD slot). This LRU destage requires the use of an internal Exchange Medium command to swap the unmount cartridge with the cartridge to be demoted from cache.

Cartridges are in the frames where the appropriate drives that can process them are also located. The TS3500 tape library without HD frame operates in *fixed-home cell mode*, which means that the cartridges are returned to their home cell. The TS3500 tape library with HD frame operates in floating-home cell mode.

Performing an inventory

With the HD frame, the inventory process is performed by using one of the following methods:

- Inventory
- Inventory with audit

Note: Make sure that 1% of the slots are free on the S54 and S24 frame so there is sufficient shuffle locations for audit process.

Inventory

An inventory is the default method. An inventory operation includes a check to determine whether each cartridge storage slot in the library is empty or full, and a scan of the bar code labels. On an HD frame, the inventory only checks Tier 1 bar code labels, and checks only the other Tier labels if Tier 1 has changed.

An inventory occurs whenever the following conditions occur:

- The TS3500 tape library is powered on.
- The library is asked to perform an inventory on the library's operator panel.
- The front door is closed after manually accessing the inventory.

Important: The TS3500 tape library tracks the logical location of all of its elements by performing an automatic inventory as required. The automatic inventory improves application performance.

When the library performs an automatic inventory because the front door was closed, the inventory occurs only for those frames whose doors were opened.

The typical time that is required for the TS3500 tape library to inventory cartridges is less than 60 seconds per frame.

Inventory with audit

The process of moving cartridges in an HD slot to scan each bar code label is referred to as an *audit*. For all inventory operations, an HD slot is only audited when one of the following changes occurs:

- A Tier 1 cartridge bar code label has changed, which is detected during inventory; only the slots where the Tier 1 label has changed are audited.
- Enough Tier 1 bar code labels have changed in a column to warrant an audit of the entire column of HD slots.
- An audit is requested via the tape library Specialist Web interface.

Important: It is recommended that manual access of HD slots be limited to the initial bulk loading of the frame because of the time that is taken to complete a full inventory with audit.

The following typical time frames are required for the TS3500 tape library to audit cartridges:

- Less than 30 seconds per HD slot.
- Less than 10 minutes to audit a column of full HD slots in a Model S54 frame.
- Less than 8 minutes to audit a column of full HD slots in a Model S24 frame.
- Performing a full inventory with audit on an HD frame takes more than 45 minutes.

Important: If the inventory with audit includes column 9 of an HD frame at the end of a library string, the inventory might take another 3 - 6 minutes.

10.1.4 TS3500 tape library (3584) High Availability Unit HA1

The TS3500 tape library (3584) High Availability Frame Model HA1 can be added to the TS3500 tape library Base Frame models. With a service bay feature on the TS3500 tape library Model D23, S24, or L23, the Model HA1 provides for the installation and operation of a second library accessor. This library accessor operates simultaneously with the first accessor and service mount requests in the TS3500 tape library. It non-disruptively fails over to a redundant accessor when any component of either accessor fails, which helps maintain availability and reliability. This design also includes the ability to add one or more Model D53 or D23 frames to a TS3500 tape library that has an attached Model HA1 with minimal disruption.

Dual active accessor support is provided in a mixed media library, which includes any combination of 3592 and LTO Ultrium media types. For example, a single library can have 3592, Ultrium 1, Ultrium 2, Ultrium 3, Ultrium 4, Ultrium 5k, and Ultrium 6 media installed and configured. ALMS is required for support of dual accessors and two or more media types. For more information, see 10.6, “Advanced Library Management System” on page 346.

When dual accessors are installed and an attached host issues a command for cartridge movement, the library automatically determines which accessor can perform the mount in the most timely manner. If the primary accessor of the library fails, the second accessor takes control and eliminates system outage or the need for operator intervention.

A dual accessor library has two garage areas called *service bays* (see Figure 10-7). When facing the front door, Service Bay A (the 3584 High Availability Frame Model HA1) is to the left of and next to the L-frame. Service Bay B (a modified TS3500 tape library Model D23 or D53) is to the right of the last active frame in the library.

The TS3500 tape library Model HA1 provides only a frame, which serves as Service Bay A for the original accessor for the TS3500 tape library Model L*xx*. The second accessor is provided by ordering the Service Bay B Configuration and Dual Accessor feature (FC1440) on a TS3500 tape library Expansion Frame Model D23 or D53. When this feature is ordered on a Model D23 or D53, that expansion frame is reserved and functions as Service Bay B for the second accessor. This feature must be initially installed on a new Model D23 or D53 Frame that is added to the TS3500 tape library when the Model HA1 is ordered.

Consider a situation where the library already contains the service bays and it is decided to add one or more D23 or D53 expansion frames. In this case, Service Bay B is converted to an expansion frame, the new frame or frames are added to the right, and the last frame on the right is converted to Service Bay B. The downtime for this process is less than one hour.

The service bays are regular library frames. They do not have drives, and depending on the ordered configuration, they have no power supplies or node cards. Storage slots within the service bays are used only to test service actions. Figure 10-7 shows how the service bays surround the other library frames.

Important: Service bays that have power supplies must not be connected to power.

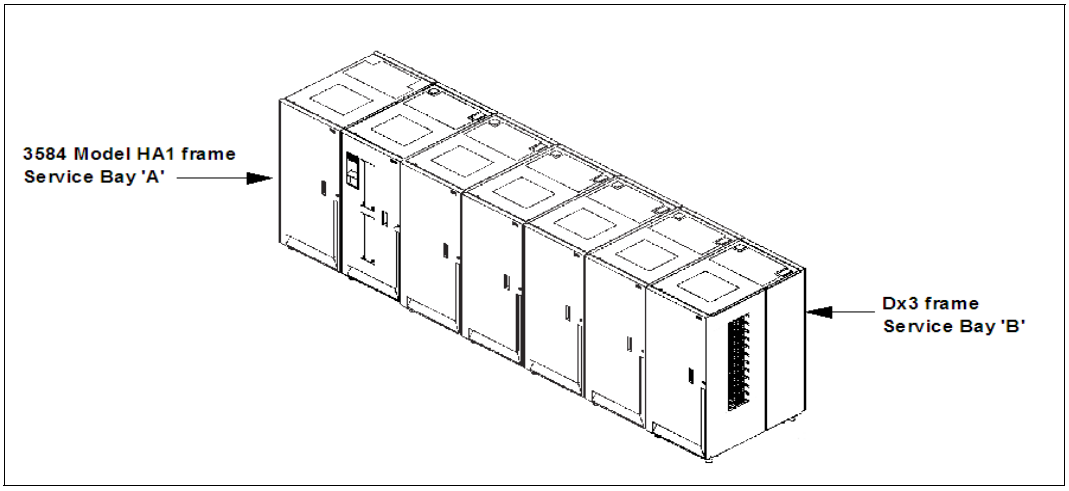


Figure 10-7 Location of service bays in the TS3500 tape library

Implementing nondisruptive accessor failover includes the following requirements:

- A 3584 Model HA1 Frame to act as Service Bay A
- High Availability Library feature (FC9040) for the L*xx* frame
- Advanced Library Management System feature (FC1690)
- A D53 or D23 frame to operate as Service Bay B for the second accessor
- Additional expansion frame attachment (FC9003)
- Service Bay B Configuration with Accessor (FC1440)

Preferred zone

In a TS3500 tape library with dual accessors, accessor A provides access to the frames in the left half of the library and accessor B provides access to the right. The location of the drive that is specified for a mount or unmount dictates which accessor performs the operation.

For example, if the drive to be mounted is in frame 1 and a move command is issued for a cartridge in frame 16, the accessor for frame 1 (accessor A) performs the mount, rather than the accessor for frame 16 (accessor B). This is the default preferred accessor zone setting.

However, to optimize mount performance for one or more logical libraries, the TS3500 tape library offers the following options for setting the preferred accessor zone:

- Frame location
- Service bay A

These options enable an accessor zone to be selected to reduce the distance the accessor must travel or the quantity of commands that are issued to an accessor.

The frame location option enables any frame to be specified in the library string as the zone boundary.

For example, if frames 1 - 4 contain 3592 tape drives and cartridges and frames 5 - 16 contain Ultrium tape drives and cartridges, the web interface can be used to specify frame 4 as the preferred zone for accessor A. Accessor A then performs operations for the 3592 tape drives while accessor B would perform operations for the Ultrium tape drives.

The service bay A option allows service bay A to be designated as the preferred zone for accessor A. This selection gives accessor A access to service bay A, while accessor B performs operations for the rest of the library string.

Preferred zone is set up by using the tape library Specialist Web interface

Important: Preferred zoning only applies to drive frames, which means that if all drives are in frame 1, 2, and 3 and preferred zoning is set at frame 4, the B assessor is never used because it has no drives to service. Correctly setting the preferred zones can improve drive mount performance.

10.1.5 TS3500 tape library Shuttle Complex (Model SC1)

The TS3500 tape library Shuttle Complex enables extreme scalability of over 300,000 LTO cartridges (or over 900 PB of uncompressed TS1140 data) in a single library image by supporting transport of cartridges from one TS3500 tape library string to another TS3500 tape library string. Application software that supports this new capability can move tape cartridges directly from its home logical library to the destination logical library. Shuttle connections span High-Density TS3500 tape library S24 or S54 frames from different TS3500 tape library strings. The TS3500 tape library Shuttle Complex supports new and existing TS3500 tape library installations and is particularly suited for HPSS (High Performance Storage System) environments.

Important: HPSS and TSLM are the library management solutions that support the TS3500 tape library Shuttle Complex.

The Shuttle Complex consists of the following main components:

- TS3500 tape libraries with model SC1
- Library Management Software (HPSS or TSLM) with Shuttle Call System (SCS)
- Total Storage System Console (TSSC)

Table 10-6 lists the capacities of the supported combinations of frames, tape drives, and their capacities, including the extreme scalability of the TS3500 tape library Shuttle Complex.

Table 10-6 TS3500 tape library configurations including Shuttle Complex

Supported Configurations			
A library including these models	**With these drives**	**Can contain this many cartridges** [1, 2]	**And has this maximum native capacity** [3]
L5x, D5x, and S54	Ultrium tape drives	> 20 000	50 PB
L32, D32, and S54	Ultrium tape drives	> 20 000	50 PB
L2x, D2x, and S24	3592 tape drives	> 15 000	150 PB
L5x, D5x, S54, and SC1	Ultrium tape drives	> 300 000	750 PB
L32, D32, S54, and SC1	Ultrium tape drives	> 300 000	750 PB
L2x, D2x, S24, and SC1	3592 tape drives	> 225 000	2250 PB

Notes:

1. All node cards in the library must be xx3-equivalent node cards. For xx2 models, this requires an xx3 model conversion or the enhanced node card feature (FC 1700 or 1701).
2. To increase the maximum number of cartridges to more than 6,887, or to support a shuttle complex, logical libraries must use LTO Ultrium 4, TS1120, or later tape drives as control path drives. To support more than 6,887 cartridges, and for logical libraries with shuttle stations assigned, it is important to check the minimum code levels that are required.
3. The maximum native capacity figures are based on library configurations with high density (HD) frames and all Ultrium 6 or TS1150 tape drives. In addition, the figures for libraries with Model SC1 (shuttle connection) are based on the maximum shuttle complex configuration.

Shuttle Complex overview

To meet the needs of large data center archives that must store increasing amounts of data, the TS3500 tape library offers shuttle technology that enables flexible library growth on a z-axis. This growth flexibility, which is enabled by shuttle connections between HD libraries, allows a higher maximum capacity for a single library image of multiple TS3500 tape library strings. This flexibility also accommodates constrained data center layouts that do not have room to expand on the x-axis, and data centers with large archives that exceed the maximum cartridge count of an individual TS3500 tape library string.

Figure 10-8 on page 308 shows the TS3500 tape library Shuttle Complex which illustrates the capability of moving tapes from one library string to another by bypassing the intermediate library strings in comparison to a traditional pass through method. The TS3500 tape library transports tape cartridges in shuttle cars that pass over the libraries. This method of transporting cartridges is called *direct flight*. With the direct flight capability, if there is no drive available in the home logical library, the cartridge is moved across a shuttle connection to a logical library with an available drive. This configuration of interconnected parallel library strings is called a *shuttle complex*.



Figure 10-8 TS3500 tape library Shuttle Complex advantage

As shown in Figure 10-9 on page 309, the shuttle complex consists of the following components:

1. Shuttle stations

   The shuttle station mounts on top of an HD frame. It consists of a base pad and a shuttle slot. The shuttle slot docks into the base pad. When the shuttle slot is positioned all the way into the frame station, it can accept or deliver a cartridge. Each shuttle station has its own import/export element (IEE) address.

2. Shuttle span

   One or more shuttle spans are linked together to form a shuttle connection between HD frames in parallel library strings. Shorter shuttle spans support distances between library strings ranging from 762 mm (30 in) to 1 524 mm (60 in). Longer shuttle spans support distances between library strings ranging from 1 524 mm (60 in) to 2 743.2 mm (108 in).

3. Shuttle Connection

   A shuttle connection consists of one shuttle car, two or more shuttle stations, and one or more spans between these shuttle stations. Each shuttle connection supports one shuttle car.

4. Shuttle car (see Figure 10-12 on page 314)

   The shuttle car is the mechanism that carries one tape cartridge through the shuttle connection to another library string. Each shuttle car carries one tape cartridge at a time.

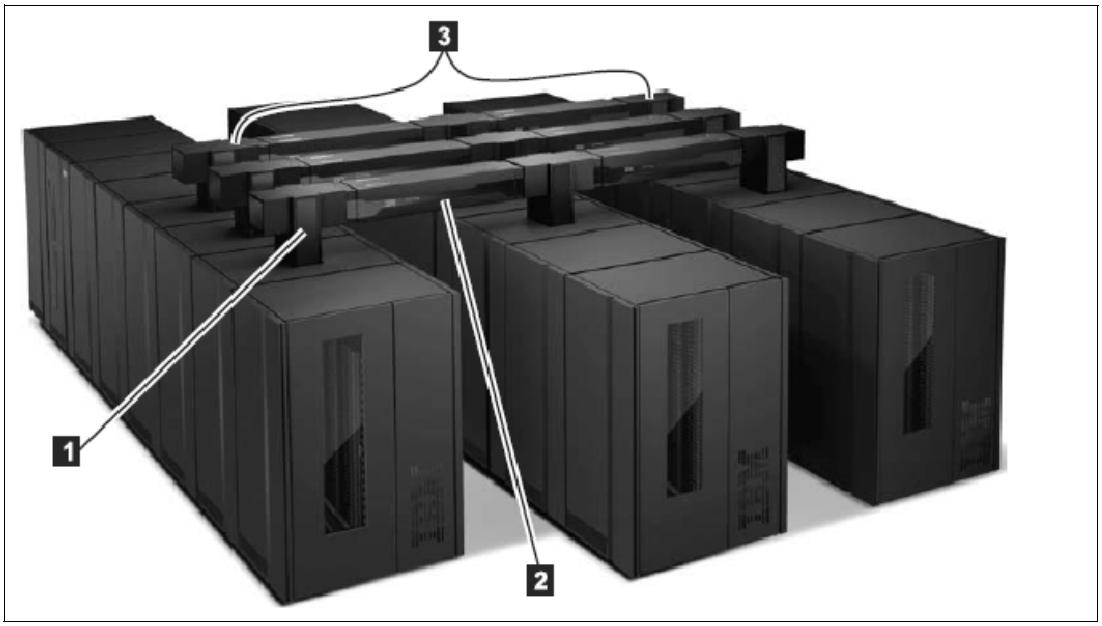


Figure 10-9 TS3500 Shuttle Complex

Physical configuration of a Shuttle Complex

A shuttle complex consists of 2 - 15 parallel library strings that are interconnected with a combination of 1- 15 shuttle connections between HD frames. Each library string in a shuttle complex has access to one or more shuttle cars that each provide at least one direct route to each of the remote library strings. (At least two direct routes are recommended for redundancy.)

A shuttle complex supports library strings with varying numbers of frames to the left or right of each connection. A shuttle complex also supports shuttle connections with varying numbers of spans. This support enables flexible shuttle complex configurations to accommodate most data center arrangements (see Figure 10-10 on page 311) and is reconfigurable if room constraints change. It is required that the front doors of each library string in the shuttle complex face the same direction.

Important: Shuttle connections attach to shuttle stations that are mounted on HD frames.

Feature codes

The Shuttle Complex consists of the following model and feature codes:

- TS3500 tape library Model SC1:
  - Main hardware components include a shuttle station and the shuttle car.
  - New model with unique serial number.
- FC 1850 - Short Span, gap 0.76 to 1.6m (30 to 63 inches):

  This feature provides all hardware for starting or extending a shuttle connection. This feature includes one short span, one shuttle station, and one station management card.
- FC 1851 - Long Span, gap 1.5 to 3.0m (60 to 105 inches):

  This feature provides all hardware for starting or extending a shuttle connection. This feature includes one long span, one shuttle station, and one station management card.

- FC 1855 - Shuttle Complex service and install kit

  This feature provides a ladder and all install tools necessary to install a shuttle system.
- IBM Super Logo rear side covers

Clearance specifications for the Shuttle Complex

This topic provides the dimensions of a TS3500 tape library Shuttle Complex and assists with the calculation of the required clearances for access and service.

The clearance specifications for a TS3500 tape library Shuttle Complex vary depending on the selected configuration. The following factors must be considered when designing and installing a Shuttle Complex is designed and installed:

- Service and operator clearance around each library string in the Shuttle Complex
- Height of ceiling and ceiling-mounted appliances
- Fire-suppression system and position of ceiling-mounted sprinkler heads

Figure 10-10 on page 311 shows a Shuttle Complex of two parallel six-frame library strings. The star indicates the operator side of the library. As shown, the front doors of each library string in a Shuttle Complex must face the same direction.

As shown in Figure 10-10 on page 311, variable dimension A shows the width of the walkway between library strings. When the short span is ordered (feature code 1850), A can range from 762 mm (30 in.) to 1 524 mm (60 in.). When the long span is ordered (feature code 1851), A can range from 1 524 mm (60 in.) to 2 743 mm (108 in.). A tolerance of +/? 50 mm (2 in.) can be applied to the maximum dimension of the short span and the minimum dimension of the long span to allow for flexibility in space planning.

Dimension B shows the minimum height of the walkway between connected library strings. This is the distance from the floor to the bottom of the shuttle connection.

Variable dimension C shows the distance between shuttle connections. If shuttle connections are mounted on adjacent frames, the distance between them is 418 mm (16.5 in.). If there are more frames between shuttle connections, it is necessary to add 782 mm (30.8 in.) per interim frame to this figure to determine the distance between shuttle connections.

Dimension D shows the maximum height of the Shuttle Complex. This is the maximum distance from the floor to the top of a shuttle connection.

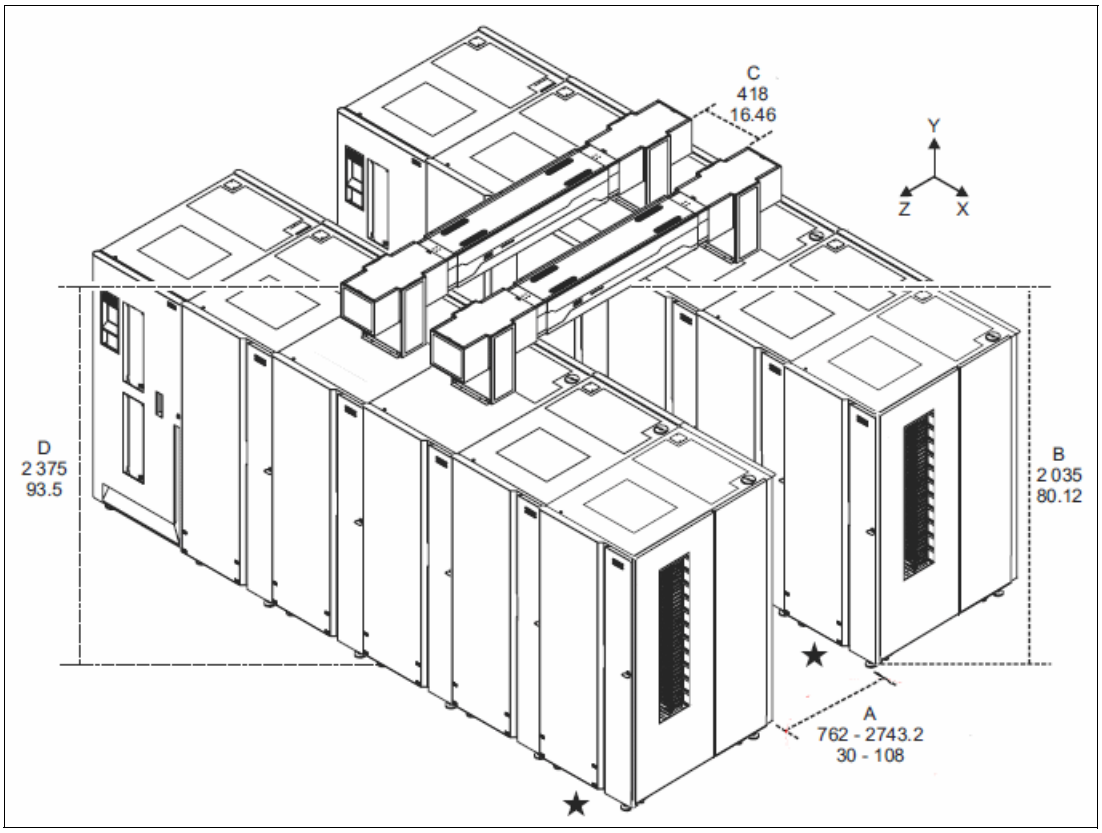


Figure 10-10 TS3500 tape library Shuttle Complex dimensions and clearances

To review and understand the physical requirements for the TS3500 tape library Shuttle Complex, see *IBM System Storage TS3500 tape library with ALMS Introduction and Planning Guide*, GA32-0593.

Logical configuration of the Shuttle Complex

A shuttle complex enables multiple TS3500 tape library strings to appear as a single library image to the host. Each library string is still its own SCSI library; however, a library manager application, such as HPSS, aggregates the multiple SCSI libraries into a single library image. This allows sharing of tape drive resources across multiple logical libraries in different library strings.

Each library string in a Shuttle Complex contains up to 192 logical libraries. Each shuttle station can be assigned to one logical library per library string or can remain unassigned. It is required that all shuttle stations on the same connection are assigned to logical libraries of the same media type. Shuttle stations are assigned to logical libraries through the TS3500 tape library web specialist interface.

Figure 10-11 shows the TS3500 tape library Shuttle System Architecture with four logical libraries.

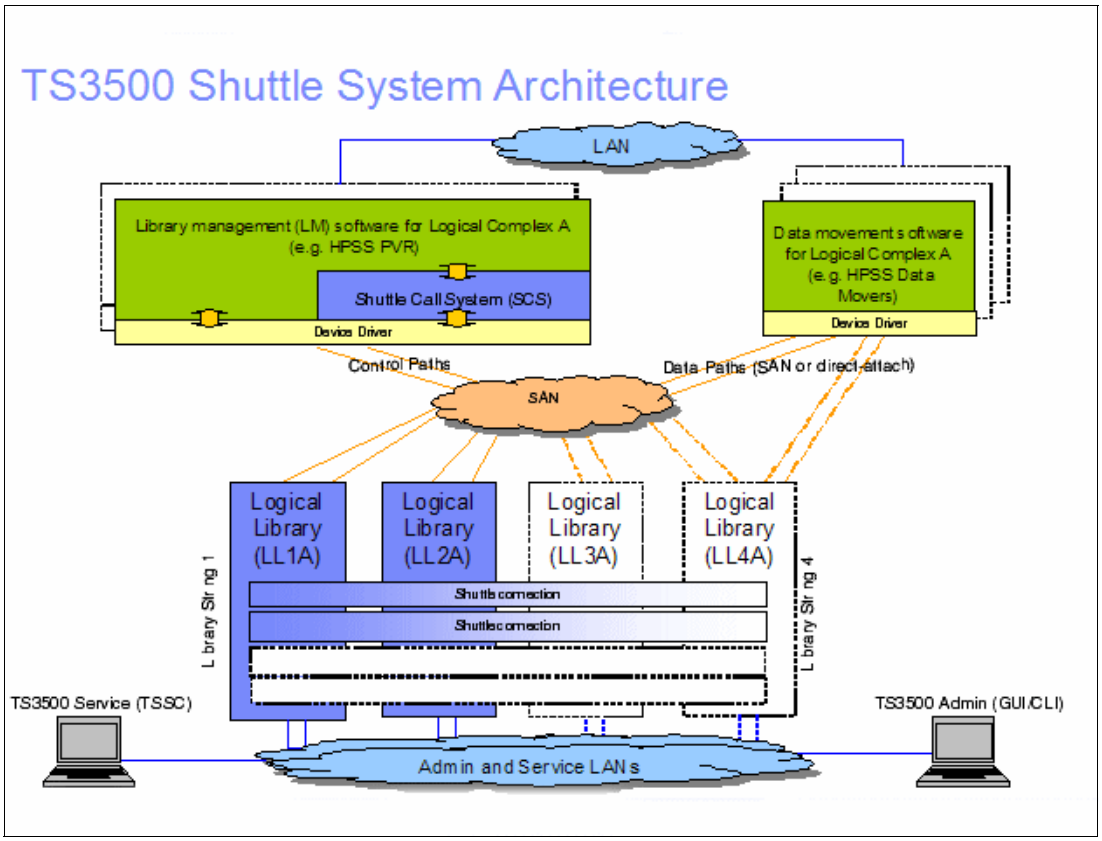


Figure 10-11 TS3500 tape library shuttle system architecture

HPSS SCSI PVR interface to the Shuttle Call System

The HPSS SCSI physical volume repository (PVR) controls a library string of up to eight logical libraries. The HPSS SCSI PVR has at least one connection to, and knowledge of, the contents of each logical library in its configuration. Furthermore, the SCSI PVR is aware of the basic connectivity between logical libraries (HPSS requires all logical libraries to have a direct connection) through the Shuttle Call System (SCS) component, which is an API for managing and controlling shuttle connections. When movement across the shuttle is necessary, the HPSS SCSI PVR also can use the SCS component to make an exclusive connection between two shuttle-connected libraries that are available for the move. Once completed, the SCSI PVR can use SCS to release this exclusive connection and that shuttle connection can serve other requests.

Performance considerations

To move a cartridge from one library string to another, the cartridge is first placed in a shuttle car by the cartridge accessor. The cartridge is then moved across the shuttle connection and is removed by the cartridge accessor at the destination library. The time for the shuttle car to move from one library to the next varies based on installation distances, but is as low as five seconds in optimal configurations.

Mount performance and cartridge move time in a Shuttle Complex depends on the overall configuration of the complex, including the length of the shuttle connections and the location of the available drive. To maximize performance, the application should only use remote tape drives if all drives are full in the home logical library.

In addition, the application can further maximize performance in a Shuttle Complex by supporting a “floating home library” algorithm so that cartridges make one-way trips rather than round trips across shuttle connections. However, such an algorithm increases the need for customer monitoring for an imbalance of cartridges across libraries that can lead to a full, or nearly full, capacity use of a library string.

Prerequisites and dependencies

The following prerequisites and dependencies are needed for the installation of the TS3500 tape library Shuttle Complex:

- Sx4 Frames (High-Density S24 and S54 frames)
- Library firmware level B5xx or higher on each library in the span:
  - Requires ALMS.
  - Requires FC 1700/1701 (enhanced node cards) for model xx2 frames.
- Shuttle car firmware should be S240 or higher. The most recent firmware level can be found at IBM Fix Central:

  http://www.ibm.com/support/fixcentral/
- TSSC:
  - TSSC is required with TS3500 tape library Model SC1.
  - Main user interface for installation and service.
- CETool 5.9 (5.11 recommended) or higher
- Library Management Software (for example, HPSS, TSLM) with Shuttle Call System (SCS)

Model SC1 components

The following components make up the TS3500 tape library Model SC1:

- Shuttle car (as shown in Figure 10-12 on page 314):
  - Cartridge tray supports LTO and 3592 cartridges.
  - Independent firmware image (not part of the library firmware image). The preferred method for updating shuttle car code is via the TSSC.
  - Maintains its own logging and is independent from library logs. The preferred method of downloading shuttle car logs is via the TSSC.

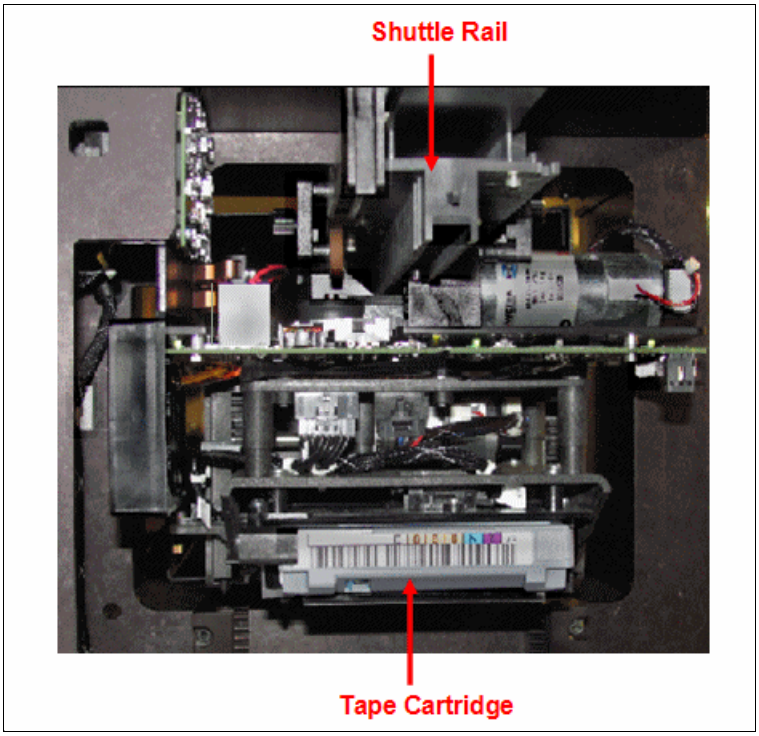


Figure 10-12 Shuttle car

- FIC panel and SMC card, as shown in Figure 10-13.

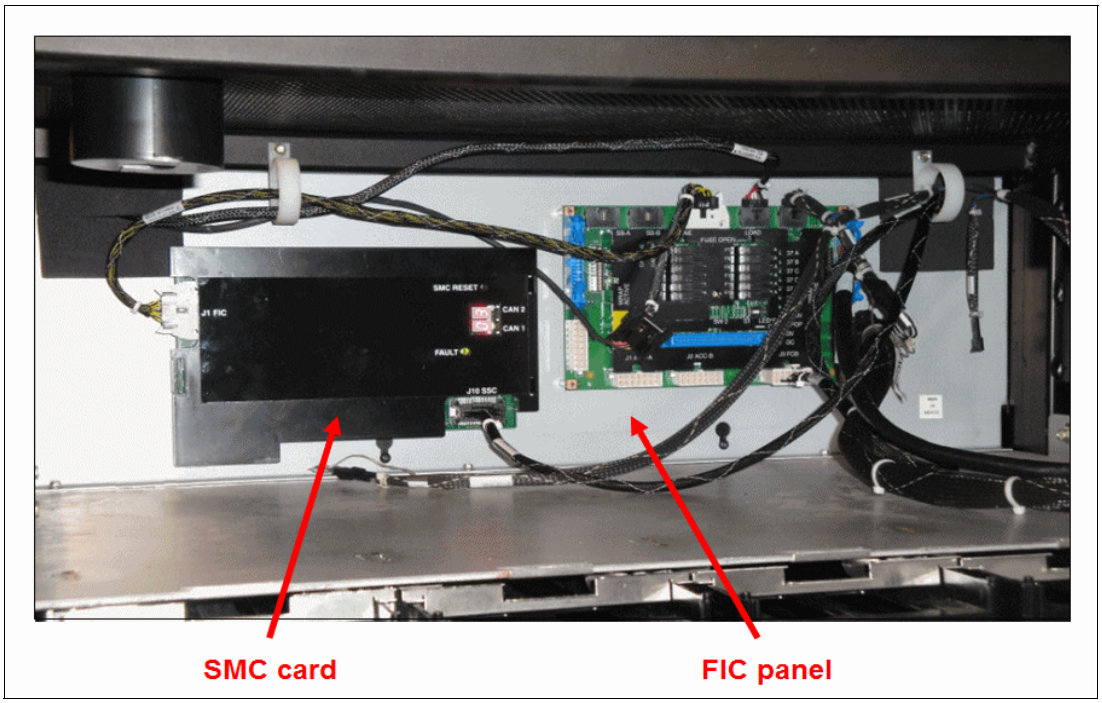


Figure 10-13 FIC panel and SMC card

- Shuttle station with SSC card, as shown in Figure 10-14.

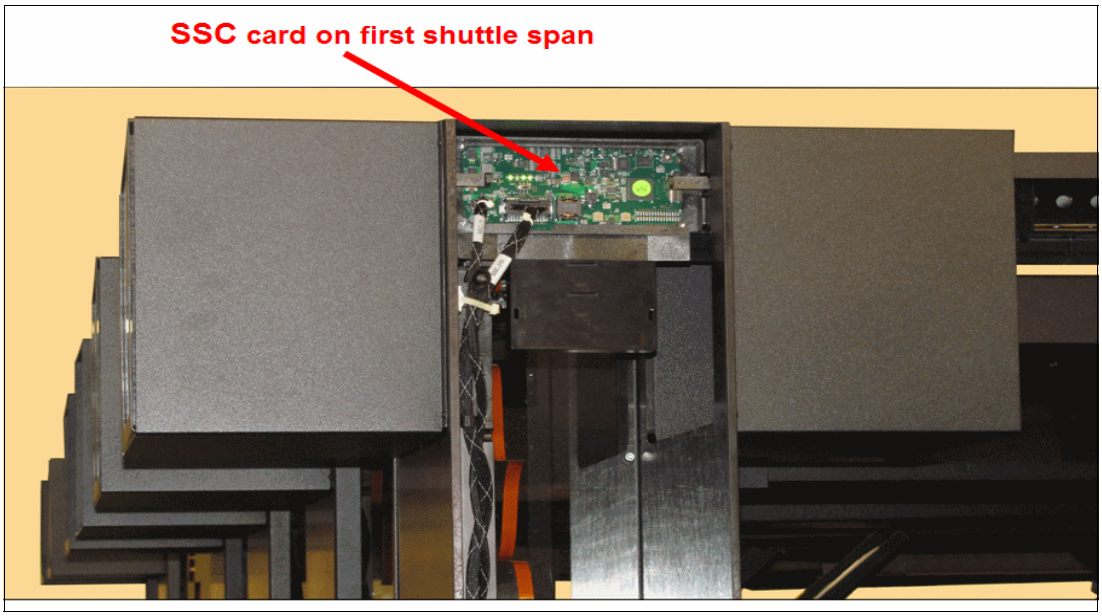


Figure 10-14 Station with SSC card

- Shuttle station rails inside Sx4 frame, as shown in Figure 10-15.

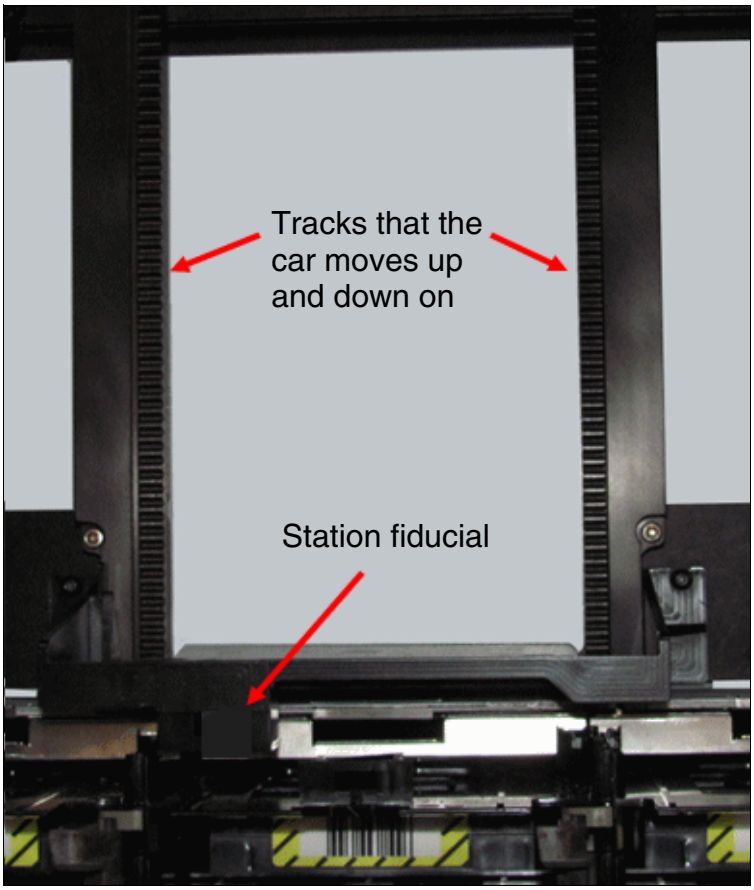


Figure 10-15 Station tracks inside Sx4 frame

- Shuttle span and covers, as shown in Figure 10-16.

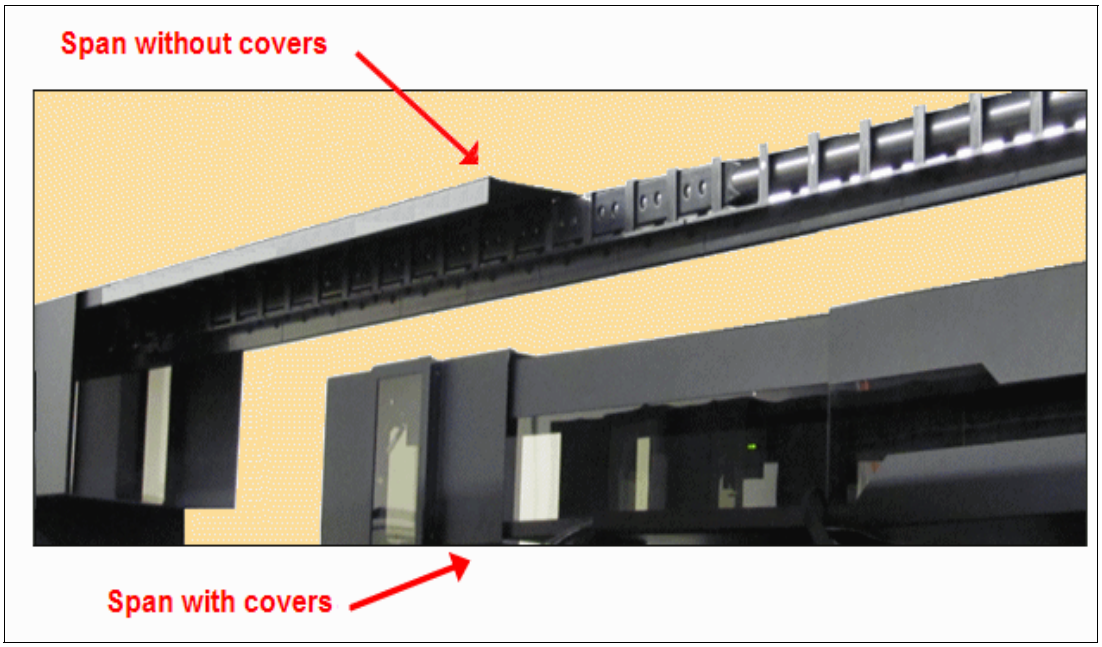


Figure 10-16 Span and covers

Figure 10-17 is a simplified diagram of the TS3500 tape library Shuttle Complex that shows the shuttle connection, shuttle span, and shuttle car that is connected between two library strings.

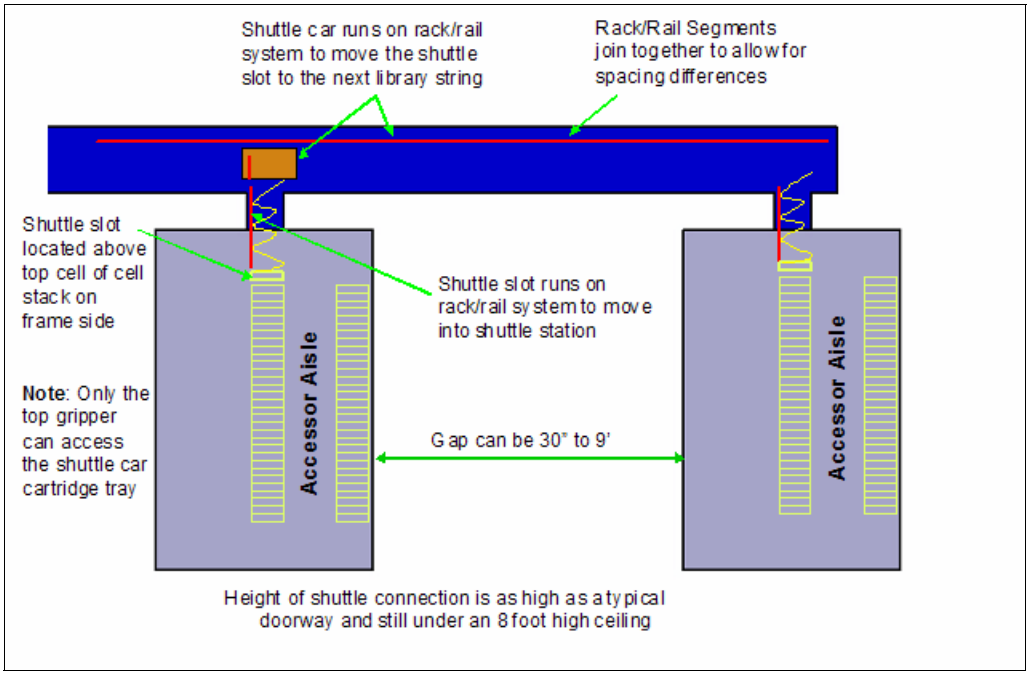


Figure 10-17 TS3500 tape library Model SC1 shuttle diagram

For more information about the physical requirements for the TS3500 tape library Shuttle Complex, see *IBM System Storage TS3500 tape library with ALMS Introduction and Planning Guide*, GA32-0593.

10.1.6 High Performance Storage System

High Performance Storage System (HPSS) is cluster-based software that manages petabytes of data on disk and robotic tape libraries. HPSS provides highly flexible and scalable hierarchical storage management that keeps recently used data on disk and less recently used data on tape.

HPSS uses cluster, LAN, or SAN technology to aggregate the capacity and performance of many computers, disks, and tape drives into a single data store of exceptional size and versatility. This approach enables HPSS to easily meet otherwise unachievable demands of total storage capacity, file sizes, data rates, and number of objects stored.

HPSS introduction

HPSS provides for overall management and access of many petabytes of data. It can concurrently access hundreds of disk arrays and tape drives for extremely high aggregate data transfer rates, thus enabling it to easily meet otherwise unachievable demands of total storage capacity, file sizes, data rates, and number of objects stored.

HPSS was used successfully for digital image libraries, scientific data repositories, university mass storage systems, and weather forecasting systems, and defense and national security applications.

HPSS is a Services Offering licensed and supported by IBM Global Business Services® in Houston, Texas. The contract documents (a Statement of Work and License Agreement) define the HPSS services and software provided by IBM.

A High Performance Computing (HPC) system needs a high performance storage system, and that is what HPSS offers. HPSS is installed in some of the greatest HPC systems worldwide, such as ORNL Titan, LLNL Sequoia, RIKEN K-Computer, ANL Mira, CEA Curie Thin Nodes, and NCAR Yellowstone.

HPSS is the result of the collaboration of the following institutions:

- IBM Global Services in Houston, Texas, US
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Oak Ridge National Laboratory
- Sandia National Laboratories

The collaborative development is important because the developers are users of the technology. So, their focus is on what is needed.

HPSS can provide an extremely scalable repository for content management software systems. HPSS can be used alone, with its own interfaces, or it can be used to provide space management and disaster recovery backup for the IBM General Parallel File System (GPFS).

HPSS technology

HPSS provides a disk and tape file repository, which uses Hierarchical Storage Management (HSM) technology with automatic migration and recall. A single instance of HPSS can concurrently access hundreds of tapes for extremely high aggregate data transfers, which make it highly scalable.

The HPSS users see it as a single UNIX file system. Its clustered architecture permits HPSS to scale horizontally almost without limits. This horizontal scaling is as easy as adding cluster components. HPSS architecture is shown in Figure 10-18 on page 318.

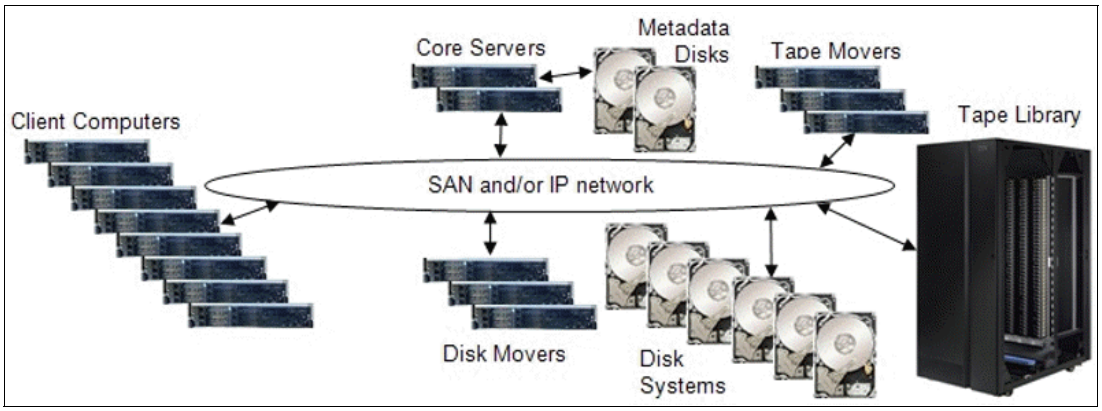


Figure 10-18 HPSS architecture

HPSS moves data objects between high performance computers, disks, and tape libraries. Speeds are limited only by the underlying computers, networks, and storage devices. HPSS can manage parallel data transfers from multiple network-connected disk arrays at hundreds of MBps. These capabilities make possible new data-intensive applications, such as high definition digitized video at rates sufficient to support real-time viewing.

HPSS can harness the power of multiple computers into a single, integrated storage system. The computers that comprise the HPSS platform can be of different makes and models, yet the storage system appears to its clients as a single storage service with a unified name space.

HPSS was designed as a set of servers that perform specialized functions, such as name services, library management, device management, and migration. The Mover is a specialized server that provides low-level device and network access. In a large HPSS installation, there are many Movers. HPSS Movers turn ordinary disks and tapes into an efficient storage network with direct paths between Movers and Clients.

A central technical goal of HPSS is to move files between storage devices and parallel or clustered computers at speeds many times faster than today's commercial storage system software products, and to do this in a way that is more reliable and manageable than is possible with current systems.

For more information about HPSS, see *IBM System Storage Solutions Handbook*, SG24-5250.

10.1.7 Tape System Library Manager

Tape System library Manager (TSLM) software provides consolidation and simplification benefits in an open systems IBM TS3500 tape library environment.

TSLM provides a resource management layer between applications such as Tivoli Storage Manager and the tape library hardware. Essentially, TSLM de-couples tape resources from applications, which simplifies the aggregation and sharing of tape resources.

TSLM can combine the capacity of multiple TS3500 libraries into a single reservoir of tape storage that can be managed from a single point, which allows more effective management, monitoring, and reporting of the use of tape storage resources for new and existing TS3500 systems.

IBM Tape System Library Manager is software that is designed to exceed today's tape storage management challenges for various customers that are involved in High Performance Computing (HPC) environments, such as oil and gas exploration and genomic analysis, where dozens of tape libraries and hundreds of tape drives must be shared and managed to back up and archive petabytes of data at the lowest cost possible. IBM TS3500 systems with a shuttle connector, Tape System Library Manager, and Tivoli Storage Manager are the ideal solution for these customers.

Tape System Library Manager provides the following abilities:

- Enables clients with large tape environments, spanning multiple TS3500 tape libraries, to manage them as a single system consists of one or more pools of drives and cartridges.
- Enables IBM Tivoli Storage Manager support for the TS3500 shuttle complex.
- Simplifies the creation and management of Tivoli Storage Manager tape drive paths to the TS3500 in the storage area network Consolidated mainframe-class media management services.
- Provides investment protection of tape drives and cartridges for customers that are using applications that are designed for the IBM 3494 tape library.

TSLM provides the following features:

- Centralized repository, access control, and administration
- Management beyond physical library boundaries:
  - Access multiple TS3500 libraries as a single TS3500 library image
  - TS3500 libraries can be separate or connected in a shuttle complex
- Dynamic sharing of resources across heterogeneous application boundaries
- Security features to permit or prevent application access to tapes:
  - Create common scratch pool and private pools for every application
  - Ensure secure use and visibility
- Policy-based drive and cartridge allocation
- Policy-based media-lifecycle management
- Tivoli Storage Manager enhancements:
  - Simplify path management in Tivoli Storage Manager
  - Simplify device sharing
- Emulation of legacy 3494 library operation with TS3500 for applications that are designed for 3494

TSLM functions

TSLM provides the following functions:

- Media management
- Library management
- Library management for Connected Media Changer
- Drive management

Media management

Media management and sharing includes the following functionality:

- The ability to identify media based on external labels (such as bar codes).
- The ability to provide for media pooling; that is, the ability to create logical groupings of physical removable media to be used for various purposes.
- The ability to share pools or groups of removable media between multiple applications in a heterogeneous SAN environment.
- The ability to share the use of media cartridges between multiple applications (through the use of command queues).

Library management

Library management and sharing include the following abilities:

- Have an abstract interface to automated libraries and autochangers.
- Inventory the contents of a library under program control to determine which tape cartridges are contained within the library.
- Audit the contents of a library to ensure that the tape cartridges that the software currently believes are in the library are physically present.
- Share use of libraries between multiple clients in a heterogeneous SAN environment.
- Provide enhanced use and workload balancing of libraries.

Library management for Connected Media Changer

Library management and sharing for the Connected Media Changer is only for the TS3500 tape library Shuttle Complex and includes the following abilities:

- Discover shuttle connections in the shuttle configuration.
- Identify connected libraries that have a shuttle connection to a specific library.
- Use direct flight to shuttle cartridges from one library to another library.

Drive management

Drive Management and sharing include the following abilities:

- Mount and unmount tape cartridges on tape drives.
- Provide a data access path for client applications to read or write from or to tape cartridges.
- Share use of drives between multiple clients in a heterogeneous SAN environment.

TSLM logical components

The main logical components of TSLM are shown in Figure 10-19.

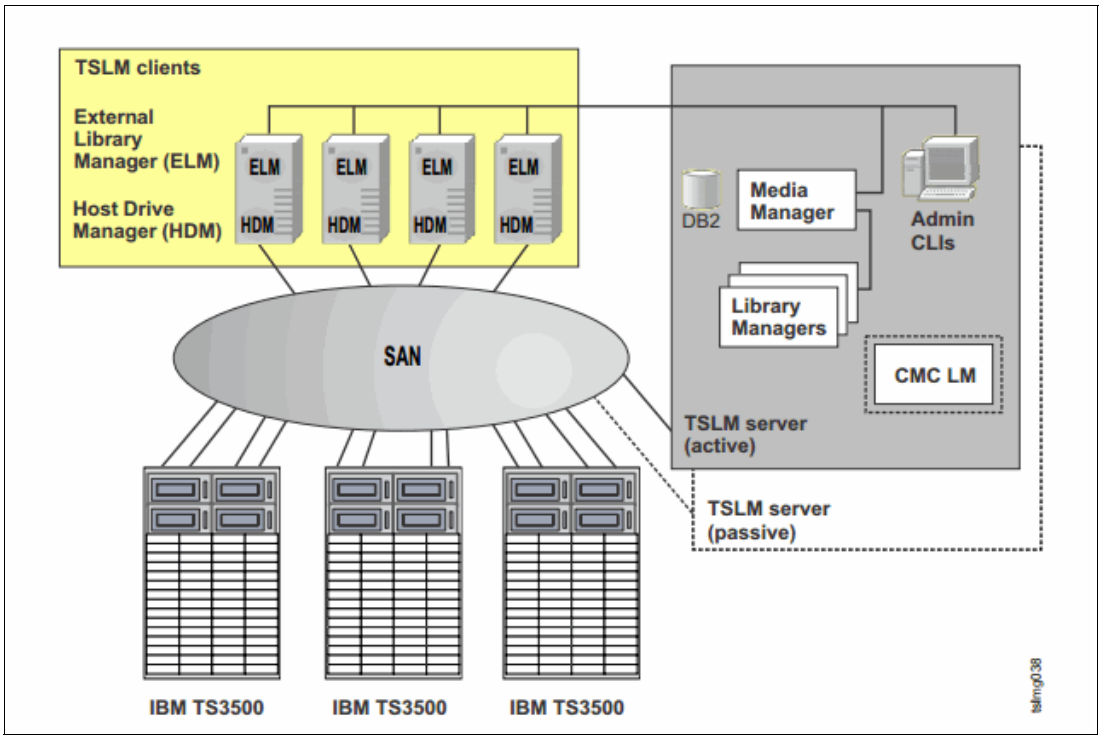


Figure 10-19 TSLM Logical Architecture

Media Manager

The Media Manager (MM) is the central server component which, among other tasks, coordinates access to drives and cartridges, handles volume allocation and de-allocation requests, and stores a log of all activities. The MM uses a TSLM bundled (and constrained) version of IBM DB2 for persistent storage.

Library Manager

The Library Manager (LM) provides the MM access to library media changers. The LM reports all slots, tape drives, and cartridges to the MM, controls libraries on behalf of the MM, and encapsulates (that is, virtualizes) the library hardware. Because of this virtualization, new library hardware can be integrated into TSLM without any changes to an installed MM.

Library Manager for CMC (Shuttle Complex)

The Library Manager for Connected Media Changer (CMC LM) provides the MM with control of the TS3500 tape library Shuttle Complex. The CMC LM discovers shuttle connections and controls movement of cartridges from one library to another by using shuttle connections.

Host Drive Manager

The Host Drive Manager (HDM) reports all local device handles to MM, issues mount and unmount commands, checks the path before a cartridge is loaded, and reports statistical data to MM when a cartridge is unloaded.

Admin Console and command-line interface

The Admin Console offers a command-line interface (CLI) that enables configuration and administration of TSLM.

External Library Manager

The External Library Manager (ELM) serves as a management layer between Tivoli Storage Manager and the TSLM Media Management software. It translates the Tivoli Storage Manager External Media Management Interface (EMMI) API into commands of the IEEE 1244 Media Management Protocol that is understood by TSLM. The ELM executable file must be on the same server that runs the Tivoli Storage Manager server for TSLM because the Tivoli Storage Manager server directly runs the ELM executable file. The ELM executable file communicates with TSLM over a TCP/IP connection.

For more information about TSLM, see T*ape System Library Manager Version 1 Release 1 User's Guide,* GA32-2208*.*

10.2 Library components

Figure 10-20 shows the major components of a TS3500 tape library L*xx* frame.

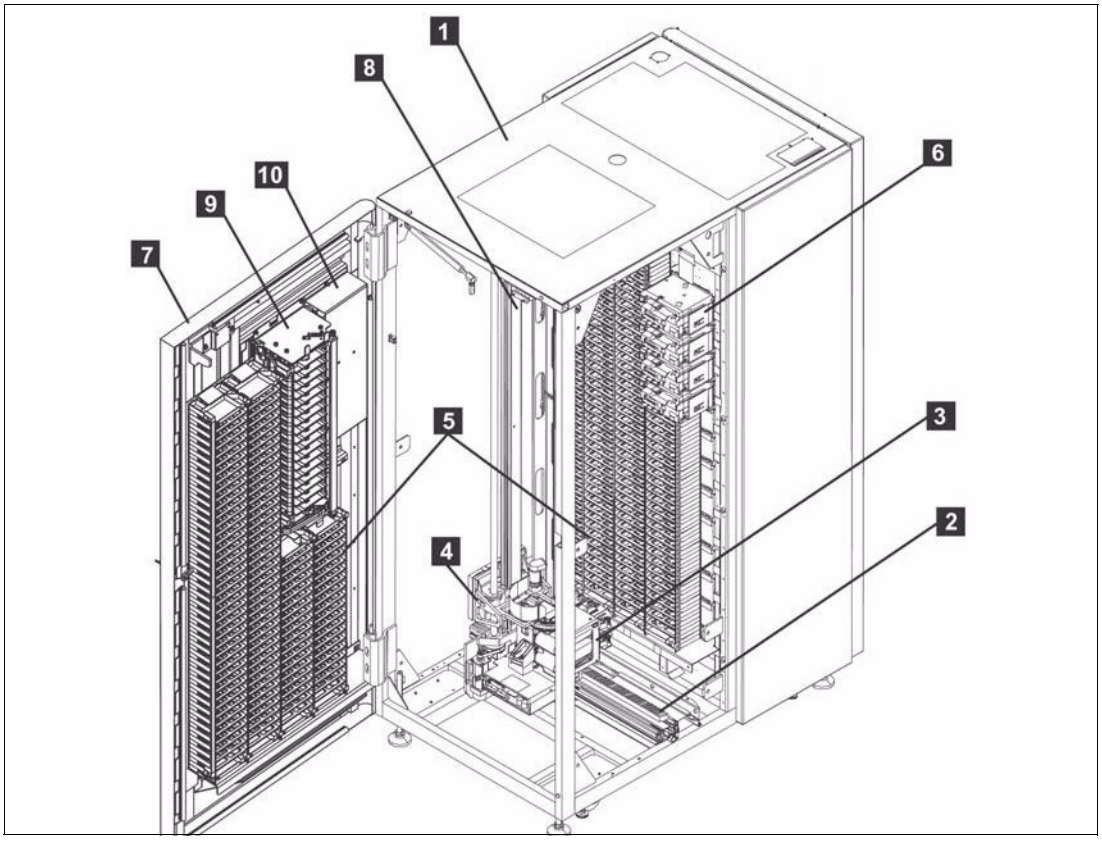


Figure 10-20 TS3500 tape library showing major library components

The numbers in Figure 10-20 on page 322 highlight the following components:

1. Library frame
2. X-rail system
3. Cartridge accessor with optimized dual-gripper transport mechanism
4. Accessor controller
5. Cartridge storage slots
6. IBM LTO Ultrium tape drives or 3592 tape drives
7. Front door
8. Door safety switch
9. I/O stations
10. Operator panel and operator panel controller

Other important components, which are not indicated in Figure 10-20 on page 322, include the frame control assembly, the enhanced frame control assembly, and the patch panel.

10.2.1 Tape drives supported in the TS3500 tape library

This section describes the types of drives that can be installed in the 3584 tape library.

The LTO Ultrium tape drives and the 3592 tape drives are high performance, high capacity, data storage units that can be installed in the TS3500 tape library (3584). Up to 12 drives can be installed in each frame of the library, but the two types of drives cannot be mixed in the same frame. A drive can be identified by examining the logo on the front of the drive or by inspecting the label on the rear of the drive canister.

LTO Ultrium tape drives

The TS1030 and TS1040 LTO tape drives have 4 Gbps Fibre Channel connectivity. The later TS1050 and TS1060 tape drives have higher speed 8 Gbps Fibre Channel connectivity. TS3500 tape library must be at minimum Licensed Internal Code level C070 for supporting the TS1060 (3588-F6A) tape drive.

When a cartridge is labeled according to proper IBM bar code label specifications, the last character of its volume serial (VOLSER) number indicates the generation of the media. For example, a cartridge with a VOLSER of `000764L5` is an Ultrium 5 cartridge, and a cartridge with a VOLSER of `003995L4` is an Ultrium 4 cartridge. To enhance library performance, Ultrium 6, Ultrium 5, Ultrium 4, Ultrium 3, and Ultrium 2 tape drives include speed matching, channel calibration, and power management. *Speed matching* dynamically adjusts the native (uncompressed) data rate of the drive to the slower data rate of a server. *Channel calibration* customizes each read/write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and read/write head characteristics. *Power management* reduces the power consumption of the drive during idle power periods.

For more information about these tape drives, see Chapter 2, “Overview of IBM LTO Ultrium tape drives” on page 41.

Important: When connecting Fibre tape drives are connected to a Fibre HBA on the host server, make sure the Fibre Channel Tape Support option is enabled on the Fibre HBA so that proper class 3 error recovery is performed on the Fibre Channel. For more information about how to set this option, see the HBA manufacturer.

IBM 3592 tape drives

IBM Total Storage 3592 tape drives include four generations of tape products: 3592 tape drive Model J1A, TS1120 tape drive, TS1130 tape drive, TS1140 tape drive and TS1150 tape drive. The 3592-J1A and 3592-E05 were withdrawn from marketing and are not covered in this section.

For more information about the E05 and J1A tape drives, see 3.8, “IBM TS1120 tape drive” on page 162 and 3.9, “IBM TotalStorage Enterprise tape drive 3592 Model J1A” on page 165.

IBM TS1130 tape drive

The IBM TS1130 tape drive (Machine Type 3592 Model E06) is the third tape drive generation of the IBM 3592 tape family. This generation provides higher capacity and performance compared to the predecessor 3592 Model E05. The TS1130 records in two new recording formats that support encryption and non-encrypted recording. Enterprise format 3 (EFMT3) represents the new non-encrypted recording format, and enterprise encrypted format 3 (EEFMT3) denotes the new encrypted recording format. With the new EFMT3 and EEFMT3 recording formats, the non-compressed capacity of the extended length MEDIA9 and MEDIA10 cartridges is increased from 700 GB to 1 TB.

The 3592 Model E06 is downward read compatible (n-2) to the 3592 Model J1A format (EFMT1) and is downward write-compatible (n-1) to the 3592 Model E05 formats (EFMT2/EEFMT2). All current media types are supported.

Host interfaces to System z and open platforms are maintained. The IBM TS1130 tape drive is supported by IBM 3592 Model J70 Tape Controller, the TS1120 Tape Controller (Model C06), and the TS7700 Virtual Engine by using 4 Gb dual port fibre cards. No support is available for the 3494 Model B10/B20 Virtual Tape Server. It allows for integration into the IBM TotalStorage 3494 tape library, the TS3500 tape library, the TS3400 tape library, a stand-alone rack, and the Oracle Silo.

The TS1130 tape drive provides the following cartridge capacity:

- 1000 GB (1 TB) with JB or JX media
- 640 GB with JA or JW media
- 128 GB with JJ or JR media

When writing in E06 mode, the data rate of TS1130 tape drive depends on the following cartridge type that is used:

- 160 MBps with JB or JX media
- 140 MBps swith JA, JJ, JR, or JW media

The TS1130 tape drive can read and write the 3592-E05 format. Compared to the TS1120, which provides a native data rate of up to 100 MBps, when writing in E05 format, the TS1130 achieves the following data rates:

- 150 MBps with JB or JX media
- 140 MBps with JA, JJ, JR, or JW media

With the E05 format, the TS1130 provides the same cartridge capacities as the TS1120. The TS1130 can reformat 3592-J1A and TS1120 media to TS1130 and TS1130 media to TS1120.

For more information about this tape drive, see 3.7, “IBM TS1130 tape drive” on page 153.

IBM TS1140 tape drive

The IBM TS1140 tape drive (Machine Type 3592 Model E07) is the fourth tape drive generation of the IBM 3592 tape family. This generation provides higher capacity and

performance compared to the predecessor 3592 Model E06. The TS1140 records in two new recording formats that support encryption and non-encrypted recording. Enterprise format 4 (EFMT4) represents the non-encrypted recording format, and enterprise encrypted format 4 (EEFMT4) denotes the encrypted recording format. With the new EFMT4 and EEFMT4 recording formats, the non-compressed capacity of the extended length Media11 and Media12 cartridges is increased from 1 TB to 4 TB.

The TS1140 tape drive does not support emulation. It reads data in EFMT2/EEFMT2 (896 tracks on 16 channels), EFMT3/EEFMT3 (1152 tracks on 16 channels), and EFMT4/EEFMT4 (2176 tracks on 32 channels) and only writes EFMT3/EEFMT3 and EFMT4/EEFMT4 format with compatible IBM 3592 tape cartridges.

Note: The TS1140 tape drive cannot read nor write by using type JA, JJ, JR, or JW cartridges.

The TS1150 E08 tape drive has a dual-port 8-Gbps Fibre Channel interface for Fibre Channel attachment to host systems or a switched fabric environment.

Host interfaces to System z and open platforms are maintained. The IBM TS1140 tape drive is supported by IBM 3592 Model C06 Tape Controller, IBM 3592 Model C07 Tape Controller, and the TS7700 Virtual Engine by using 8 Gb dual port fibre cards. It allows for integration into the TS3500 tape library and a stand-alone rack.

The TS1140 tape drive provides the following cartridge capacity:

- 4000 GB (4 TB) with JC or JY media (Media11 and Media12)
- 1600 GB with JB or JX media (Media9 and Media10)
- 500 GB with JK media (Media13)

The native data rate for the TS1140 tape drive is up to 250 MBps.

The TS1130 and TS1140 Tapes Drives feature an Ethernet port for use by an IBM Service Support Representative for procedures such as updating Licensed Internal Code or viewing drive status.

For more information about this tape drive, see 3.6, “IBM TS1140 tape drive” on page 142.

IBM TS1150 tape drive

The IBM TS1150 tape drive (Machine Type 3592 Model E08) is the fifth tape drive generation of the IBM 3592 tape family. This generation provides higher capacity and performance compared to the predecessor 3592 Model E07.

The TS1150 records in two new recording formats that support encryption and non-encrypted recording. Enterprise format 5 (EFMT5) represents the nonencrypted recording format, and enterprise encrypted format 5 (EEFMT5) denotes the encrypted recording format. With the new EFMT5 and EEFMT5 recording formats, the noncompressed capacity of the extended length Media11 and Media12 cartridges is increased from 4 TB to 7 TB and MEDIA 14 and 15 cartridges to 10 TB.

The TS1150 tape drive does not support emulation. It reads and writes data only in EFMT4/EEFMT4 (2176 tracks on 32 channels) and EFMT5/EEFMT5 (5120) tracks on 32 channels) with compatible IBM 3592 tape cartridges.

Note: The TS1150 cannot read or write to a JA, JW, JJ, JR, JB, or JX media.

The TS1150 E08 tape drive has a dual-port 8-Gbps Fibre Channel interface for Fibre Channel attachment to host systems, or a switched fabric environment.

The TS1140 tape drive provides the following cartridge capacity:

- IBM Enterprise Advanced WORM with data media (JZ, JD), a capacity of 10 TB
- IBM Enterprise Advanced WORM with data media, (JC, JY), a capacity of 7 TB
- IBM Enterprise Economy Data media (JZ), a capacity of 2 TB
- IBM Enterprise Economy Data media (JK), a capacity of 900 MB

The native data rate for the TS1140 tape drive is up to 360 MBps in E08 format.

The TS1140 and TS1150 tapes drives feature an Ethernet port for use by an IBM Service Support Representative for procedures such as updating Licensed Internal Code or viewing drive status.

For more information about this tape drive, see 3.5, “IBM TS1150 tape drive” on page 124.

10.2.2 Library control systems

A library control system is required for a library to operate. Conventional libraries, such as the IBM 3494, use a single library controller that handles all of the different inputs and controller output commands. The TS3500 tape library uses a system of distributed embedded controllers, each with its own processor.

Controller Area Network

The Controller Area Network (CAN) is a serial bus system that complies with ISO Standard 11898. Developed originally for passenger cars, CAN is used in millions of industrial control devices, sensors, and actuators. Features of the system include simplicity and high transmission reliability.

In the TS3500 tape library (3584), the CAN bus communicates with all the node cards. A CAN bus features the following functions:

- Broadcasts communication from the Access Controller Card (ACC) to all node cards.
- Provides point-to-point communication between the controller nodes.

Node cards

The TS3500 tape library contains controller cards, which are referred to as Node cards. There are four types of Node cards in a TS3500 tape library. Although some might appear to be more than just a card, they are called Node cards because they function much like nodes on a LAN. They all communicate with each other by sending messages over the Controller Area Network (CAN) bus.

The four Node cards are in different locations. The operator panel controller is directly on the operator panel. The accessor and MDA cards are attached to the accessor. The MCA is above the drives, as shown in Figure 10-21 on page 327.

A distributed control system has the following advantages:

- Improved reliability:
  - Reduces single points of failure.
  - Smaller field-replaceable unit (FRU) components.
- Simplified library repair

  Functionality is isolated to a single area of the library.

- Easier upgrades:
  - Power and communication wires are required for distributed components.
  - Modular design for a “building block” approach.
- Better performance than a single library controller.

  Each major library component has its own processor.

Medium Changer Assembly or Media Changer Pack

Depending on the TS3500 tape library frame model and configuration, the frame contains a Media Changer Pack (MCP) (model x32, x22, x52) or a Media Changer Assembly (MCA) (model x23/x5).

In the rear of an LXX and DXX frame, this card controls powering up, handles all communications to the drives with RS-422, and communicates with the rest of the cards by using the internal Controller Area Network (CAN) in the library. It has a serial interface for Call Home and two Ethernet interfaces: one interface to connect to the tape library Specialist web interface (Port A) and one interface for the TS3500 System Console (TSSC), (Port B), as shown in Figure 10-21.

Figure 10-21 also shows the physical difference between an MCA and an MCP. The enhanced model of MCP with two Ethernet ports is shown.

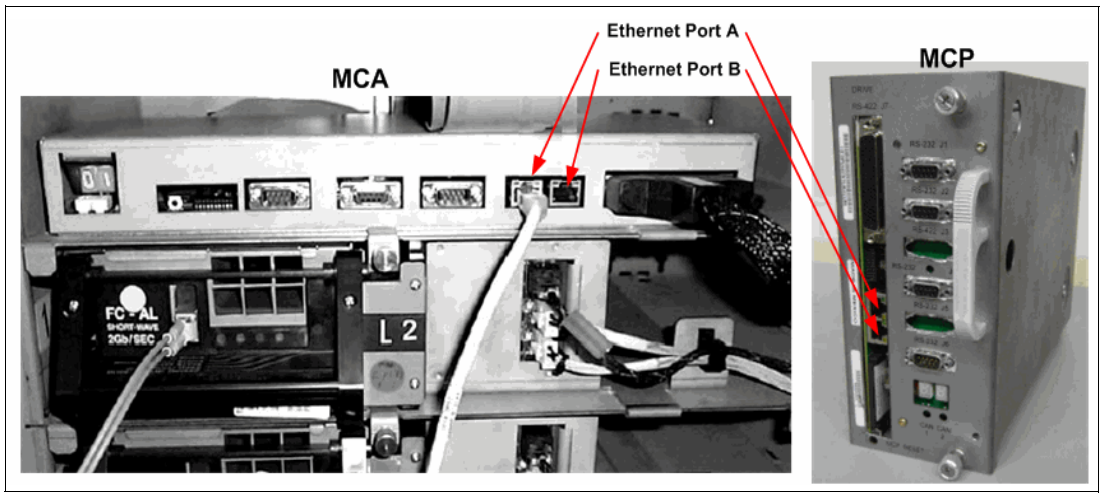


Figure 10-21 MCA and MCP

Port A is used to connect to a user’s management network for web management of the TS3500 tape library.

Port B can be used for TSSC attachment to provide the Call Home feature of the TS3500 tape library, which is described in 10.3.2, “Remote support” on page 338.

The Call Home feature retrieves library and drive logs (and other pertinent information) and saves them to the IBM Remote Technical Assistance Information Network (IBM RETAIN®) where they can be examined for failure and maintenance analysis. In the past, this task was done by using an analog modem that was attached to a serial port or by using an Ethernet port in a second frame that was connected to the TSSC. The second frame was necessary because the TSSC required a private network that was separate from the client network. The dual Ethernet ports of the MCA and new model MCP make the Ethernet port in a second frame unnecessary. Ethernet cables to the MCA or MCP can be routed through the top or bottom of the frame.

Up to five web sessions can be established to the tape library Specialist by using one physical Ethernet port. If there are multiple D*xx* frames, a connection per frame can be added.

Important: An MCP or MCA node card is installed on all DXX frames with drives installed.

Operator Panel Controller

The Operator Panel Controller (OPC) node card is in the front door of an LXX frame and has the following functions:

- Directly operates the I/O station lock solenoid and monitors the I/O station sensors.
- Performs all the front panel operations, including displaying status, which performs manual operations.
- Contains a backup of the library configuration, calibration, VPD, error logs, and inventory.
- Contains the real-time clock.

Accessor Controller Card

The Accessor Controller Card (ACC) node card is the controller for the accessor mechanism. This node card is on the side of the accessor assembly and each accessor assembly has one. This controller has the following functions:

- Contains the master copy of the library configuration, calibration, VPD, error log, and inventory.
- Provides high-level control of all cartridge movement by issuing commands to the Motor Drive Assembly (MDA), when left-to-right (X axis) and up/down (Y axis) motion is required.
- Directly operates the pivot mechanism, grippers, calibration sensor, and bar code reader.
- Controls redundant 37 v dc power within the entire library.

Motor Drive Assembly

The Motor Drive Assembly (MDA) node card has several functions that are related to the X axis, Y axis, and home sensors. It is on the accessor assembly. Each accessor assembly has one and includes the following functions:

- Directly controls the X axis and Y axis servo motors.
- Performs the X axis and Y axis rezero functions when commanded by the ACC.
- Contains the dynamic brake card, the XY controller, and the XY motor amps.
- Triggers the bar code scanner, allowing high-speed inventory3.
- Controls fine movement by the accessor as directed by the ACC.

Enhanced Frame Control Assembly

The Enhanced Frame Control Assembly is an improvement over the previous frame control assembly that is found in model L32, D32, LX2 and DX2 because it incorporated a 2N redundant power design and fewer components than the original frame control assembly.

The Enhanced Frame Control Assembly has two redundant power supplies, which are fed directly by independent dual AC power cords. The assembly is constructed with hot-swappable, redundant parts, which (along with the dual ac power cords) remove the possibility of a single part causing failure. If one power supply fails, the remaining power supply provides all of the power to all elements of the library.

The Enhanced Frame Control Assembly comes standard with models L23, D23, L53, and D53. Dual AC power cords are standard on these models and do not have to be ordered separately.

10.2.3 Operator interface

The operator interface, which is on the front of the LXX frame (see Figure 10-2 on page 294), provides a set of indicators and controls that enables an operator to perform operations and determine library status. The panel (as shown in Figure 10-22) consists of the library power switch, a power-on indicator, power switch door (L53 and L23 frames only), a touch-sensitive panel LCD and controller, and the controller for the I/O station. The operator panel controller is inside the library behind the operator panel (10 in Figure 10-20 on page 322). It is a logic card that facilitates communication between the operator panel and the accessor controller. The operator panel controller posts status and information about the sensing and locking of the I/O station to the operator panel LCD.

The operator panel touch-sensitive LCD consists of the touch keys area and the activity panel as shown in the expanded area of Figure 10-22. The activity panel shows a `Ready` message on the touch-sensitive panel when the library is ready (that is, when host applications can interact with the library). The first line on the panel shows the current level of library firmware and the panel number. The left field on the second line indicates that the library is ready, not ready (not interacting with host applications), or initializing. The right side field indicates the status of one or more I/O stations. The activity panel also shows the current activity in a large font and provides a history of preceding operations in a smaller font. Operations are listed from top to bottom, with the most recent operations at the top. The activity screen automatically shows an error message when an error condition is detected. For more information, see 10.9, “Specifications” on page 354.

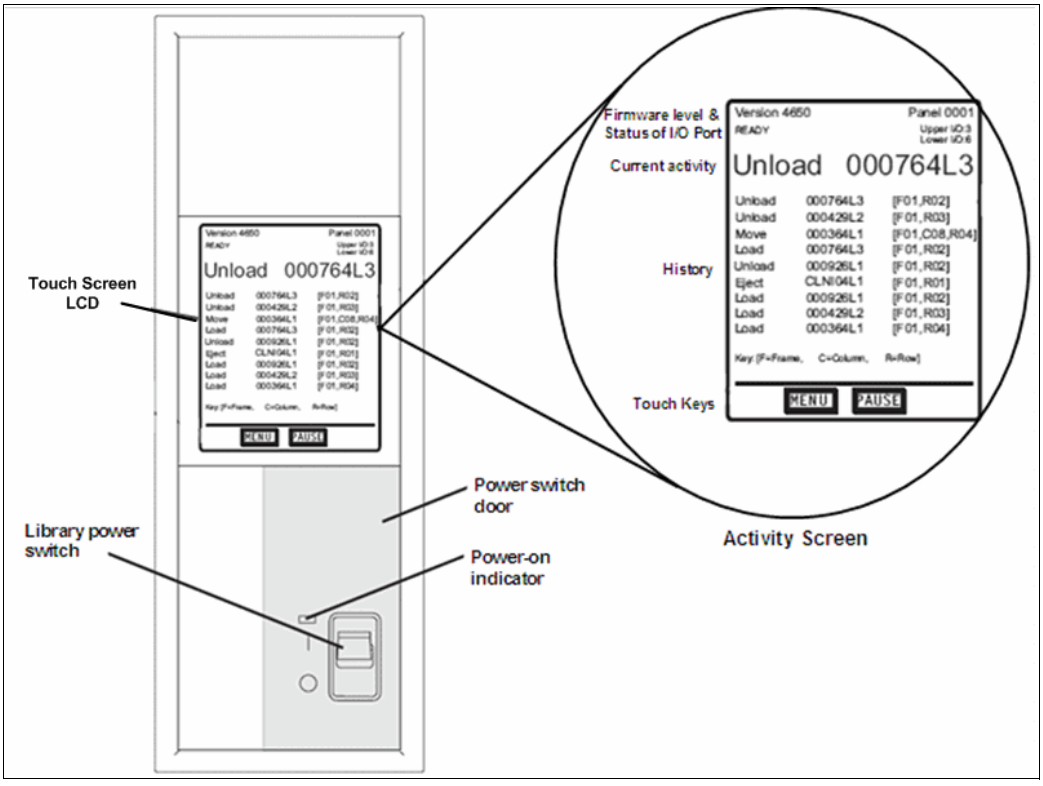


Figure 10-22 Operator panel

Security can be enabled on the operator interface. The operator panel is then password-protected, and a time interval can be set. A timeout period can be specified that, when exceeded, causes the operator panel to lock.

10.2.4 Robotic cartridge accessor

The *cartridge accessor* is the assembly that moves tape cartridges between storage slots, tape drives, and the I/O station (3 in Figure 10-20 on page 322). The accessor assembly moves horizontally through the library frames by using a rail system (2 in Figure 10-20 on page 322). It uses the top and bottom rails.

The accessor assembly consists of an optimized dual gripper (4 in Figure 10-20 on page 322 and in more detail in Figure 10-23) mounted on a vertical pole. The gripper can move up and down vertically and rotates to access cartridge slots on the back walls and front doors of the library frames. In libraries that mix drive types, the optimized dual grippers can house both Ultrium and 3592 tape cartridges. Thus, if one gripper fails, another gripper acts as a backup to process a cartridge. The enhanced gripper is designed for the HD frame. A bar code reader is mounted on the accessor and can scan the cartridges in one frame in less than one minute.

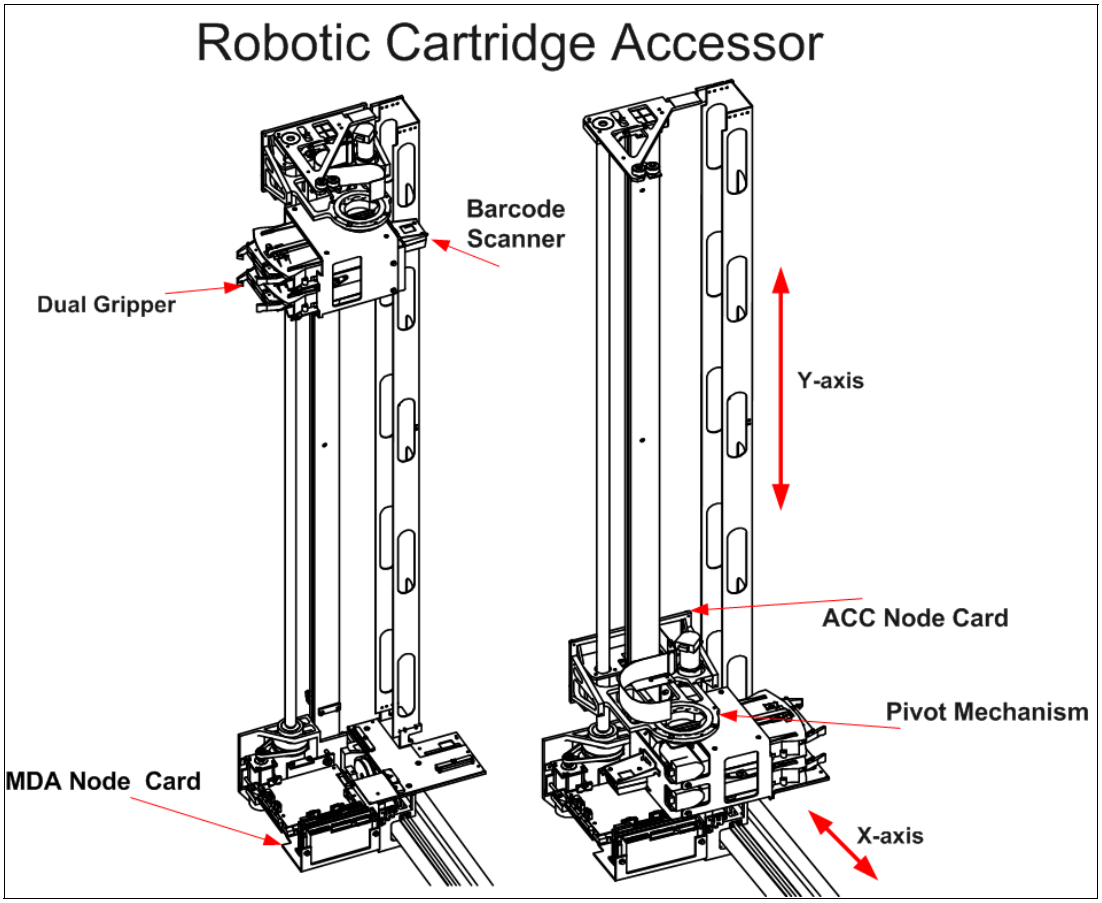


Figure 10-23 TS3500 tape library accessor assembly

X-axis and Y-axis motion assemblies

The X-axis and Y-axis motion assemblies include a controller (circuit board) for the Controller Area Network interface, servo motor, pinion drive gear, and lead screw. These assemblies provide the motive force to move the accessor side to side (on the X-axis) and up and down (on the Y-axis). The controller part of this assembly is referred to as the MDA, as shown in Figure 10-23.

Pivot assembly

The pivot assembly provides a mounting platform for the gripper mechanism and the bar code reader. This assembly supports 180-degree rotation around the vertical axis, as shown in Figure 10-23 on page 330.

Optimized dual gripper

The electromechanical, optimized dual gripper device (mounted on the pivot assembly), gets or puts cartridges from or to a storage slot, tape drive, or I/O station.

The gripper is independently controlled and can grip a single cartridge. Two grippers are on the pivot assembly (Gripper 1 and Gripper 2), as shown in Figure 10-23 on page 330. The gripper that is installed in L5X or L2X can handle LTO and 3592 tape cartridges. It can be changed without any tools and was redesigned to eliminate weak points, therefore improving its lifetime. The cartridge presence sensor also was simplified. The original gripper in L32 must be replaced by ordering feature support (FC1608) to handle LTO and 3592 media.

Tip: The gripper that is installed in L5X or L2X can handle LTO and 3592 tape cartridges, which provide gripper redundancy in a mixed LTO/3592 library.

Many libraries offer support for different drives and media, such as LTO, digital linear tape (DLT), or Advanced Intelligent Tape (AIT). Typically, they use a universal gripper for cartridge handling. Clam shell grippers are a common design approach. This universal gripper might decrease performance and reliability, because a “catch-all” gripper cannot be optimized for each media type. The LTO (and the 3592) cartridge was designed with automation in mind, and IBM was a key player in this effort. The cartridge contains automation handling features, such as the notches that are shown in Figure 10-24. The TS3500 tape library gripper takes advantage of the handling features and uses hooks to handle the cartridge. This approach offers significant performance improvements (as described in 10.4, “Performance” on page 344) and is more reliable than a catch-all gripper.

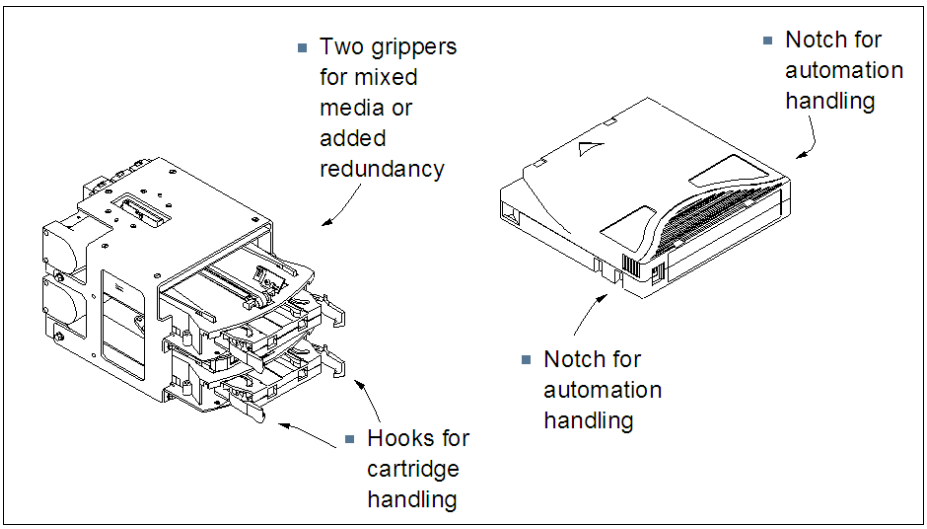


Figure 10-24 TS3500 tape library gripper

The use of a dual-gripper accessor reduces the time taken to move cartridges in the library and can improve overall performance on large libraries. It also increases redundancy and reliability. Library functions are controlled by host application software. To use the dual gripper function, the software must be able to use two grippers simultaneously. If it does not, the library functions as though it had only a single gripper. If only one gripper is used at a time, the library periodically switches between both grippers to balance use.

Enhanced gripper for the HD frame

The enhanced gripper for the HD frame has minor changes to the current gripper design. The current aluminum gripper plate is replaced by a plastic mold, as shown in Figure 10-25. The HD gripper is a requirement if an Sx4 (HD) frame is installed. The gripper has motors that enable the gripper to put tapes into the different tier of the HD frame.

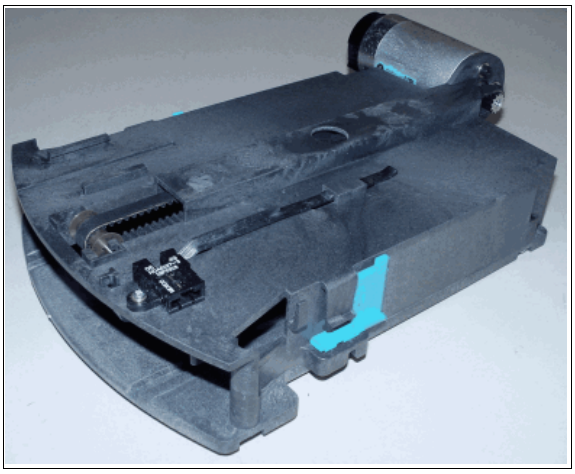


Figure 10-25 HD gripper

Bar code reader

The bar code reader scans the bar code on a label that is attached to a cartridge, or at the rear of every storage slot (which indicates an empty storage slot). The bar code reader is mounted on the pivot assembly, as shown in Figure 10-23 on page 330, and is used during inventory process, audits, I/O insertions, and inventory updates. The inventory is updated whenever the door is opened, and it determines whether cartridges were added to, removed from, or moved within the library.

Because all storage slots have empty storage cell labels, the library can easily and quickly recognize whether there is a labeled cartridge or an empty storage slot in every location. This detection eliminates the need to reread or manually intervene in storage cells if no label is readable. Without this approach, the library cannot differentiate between a slot that is unlabeled, badly labeled, or empty.

Calibration sensor

The calibration sensor provides a means to locate certain positions within the library precisely during the calibration operation. The calibration sensor is mounted on the underside of gripper 1. (For the optimized dual gripper, the sensor is mounted on the top of gripper 2.) All positions are calculated from these locating positions. Calibration occurs because of a service action or when the library firmware detects a change in the library.

10.2.5 Rail assembly

The cartridge accessor moves through the library on a rail assembly (2 in Figure 10-20 on page 322). The system consists primarily of a main rail assembly, support rail, and a trough for the power and control cable. The main rail assembly includes a main bearing way with a rack gear. Its support rail is an L-shaped rail that runs along the top of the frames and provides smooth transport for the cartridge accessor. The power and control cable is kept clear of the accessor in a covered trough at the bottom rear of the library.

10.2.6 Library-centric WWNN convention

Every device in a storage area network (SAN) environment uses a unique worldwide node name (WWNN) for identification in the SAN. In a conventional library, if the drives are swapped, the WWNN also is changed. Therefore, the SAN and the server must be reconfigured. If persistent binding is used on the server, a server restart also is necessary.

The TS3500 tape library assigns the WWNs to the drive slots. This technique is referred to as *library-centric worldwide names*. Every potential drive slot is assigned a unique worldwide name (WWN). If a drive is replaced, the new drive gets the same WWN as the old drive. The name is controlled by the MCA. Because of this library behavior, the position of the drive can be easily identified in the library by the WWNN. The last two digits represent the location of the drive in the library. The last digit indicates the drive row, starting from 1, and the second to last digit indicates the frame, counting from 0. The remaining digits are encoded with the vendor ID and the library-specific data, ensuring that every drive has a unique WWNN.

Figure 10-26 shows the drive WWNs in a TS3500 tape library.

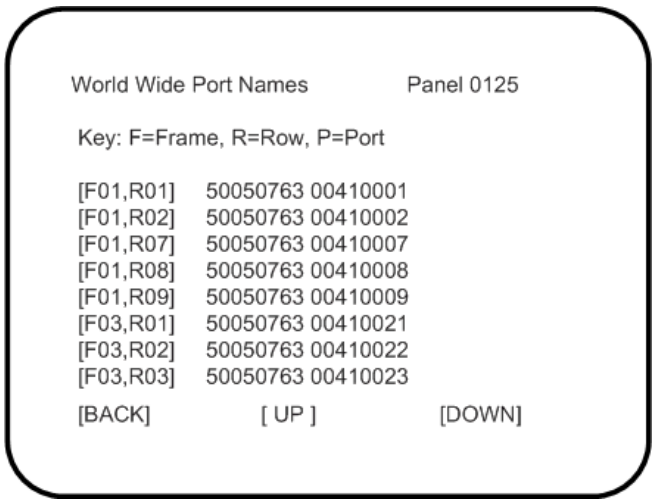


Figure 10-26 Drive WWNs of a TS3500 tape library

10.2.7 Control path failover

Alternative path support, which is available for AIX, Linux, Solaris, HP-UX, and Windows hosts, configures multiple physical control paths to the same logical library within the device driver. It also provides automatic failover to an alternative control path when a permanent error occurs on one path, which is not apparent to the running application.

For example, consider a simple multipath architecture connection that consists of two host bus adapters (HBAs) in a host that is connected to a library with two or more drives, as shown in Figure 10-27. Two drives have the control ports enabled. The two HBAs are connected to the first and second control port drives. This simple configuration provides two physical control paths to the library for redundancy if one path from an HBA to the library fails.

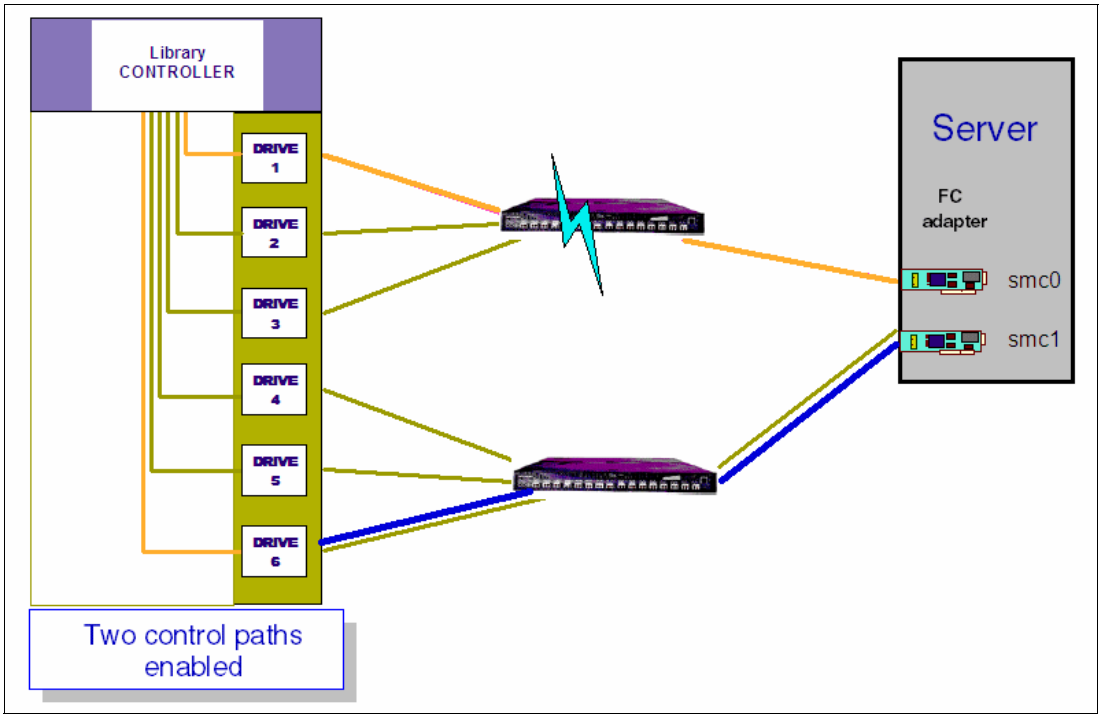


Figure 10-27 Redundant control paths to the library controller

When the server boots up, each HBA detects a control port to the library, and two medium changer devices (`smc0` and `smc1`) are configured. Each logical device is a physical path to the same library. However, an application can open and use only one logical device at a time, `smc0` or `smc1`.

Without the device driver alternative pathing support, if an application opens `smc0` and a permanent path error occurs (because of an HBA, cable, switch, or drive control port failure), the current command to the library fails. It is possible to initiate manual failover by changing the device path to the alternative path (`smc1`), but operation is manual, and the last failing command must be resent.

When the alternative pathing support is enabled on `smc0` and `smc1`, the device driver configures them internally as a single device with multiple paths. The application can still open and use only one logical device at a time (`smc0` or `smc1`). If an application opens `smc0` and a permanent path error occurs, the current operation continues on the alternative path without interrupting the application.

Activation of the Control Path Failover is done by entering a license key at the library operator panel. Control path failover is provided by an optional FC1680 for L*x*2 frame models and requires the use of the IBM device driver. For L*x*3 models, Control Path Failover and Data Path Failover are available with the optional Path Failover feature (FC1682).

10.2.8 Data Path Failover

Data Path Failover and load balancing exclusively support native Fibre Channel Ultrium and IBM 3592 tape drives in the TS3500 tape library by using the IBM device driver. Data Path Failover is now supported for AIX, Linux, HP, Solaris, and Windows hosts. Load balancing is supported for AIX, Linux, and Solaris. For more information about support and implementation, see *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430.

Data Path Failover provides a failover mechanism in the IBM device driver so that multiple redundant paths can be configured in a SAN environment. If a path or component fails, the failover mechanism provides automatic error recovery to try the current operation again by using an alternative, preconfigured path without stopping the current job in progress. This feature improves flexibility in SAN configuration, availability, and management.

When a tape drive device that is configured with alternative pathing across multiple host ports is accessed, the IBM device driver automatically selects a path through the HBA that has the fewest open tape devices. It assigns that path to the application. This autonomic self-optimizing capability is called *load balancing*. The dynamic load balancing support optimizes resources for devices that have physical connections to multiple HBAs in the same machine.

The device driver dynamically tracks the use on each HBA as applications open and close devices and balance the number of applications by using each HBA in the machine. This feature can help optimize HBA resources and improve overall performance. Further, Data Path Failover provides autonomic self-healing capabilities similar to Control Path Failover, with not apparent failover to an alternative data path if a failure occurs in the primary host-side path.

Data Path Failover and load balancing for Linux and Solaris are provided by an optional feature (FC1681) for L*x*2 models. Data Path Failover is included in the Path Failover feature (FC1682) for L*x*3 models, which include Control Path Failover.

Data Path Failover and load balancing support for AIX or for IBM 3592 tape drives do not require this feature.

10.3 Tape Library Specialist Management Interface

By using the web UI of the TS3500 tape library, operators and administrators can manage storage devices from any location in an enterprise. The TS3500 Tape Library Specialist enables direct communication with a TS3500 tape library and provides a full range of user, operator, and administrator tasks, which can be run remotely.

Firmware for the library and drives can be updated non-disruptively if the web UI is used. Non-disruptive library firmware updates require that a library control path with an LTO-3, 4, 5, or 6 tape drive is used. LTO-1 and LTO-2 drives receive a SCSI Reset command during the firmware installation.

The Management Interface (MI) can be opened on any device with a network connection into the same management network, and with a web browser that meets the following minimum specifications:

- Internet Explorer 5.0 (or higher)
- Firefox 1.0 (or higher), or
- Opera 2.5 (or higher)

The IP address of the TS3500 tape library is entered into the address bar of the browser.

An example of the system summary page of the MI is shown in Figure 10-28.

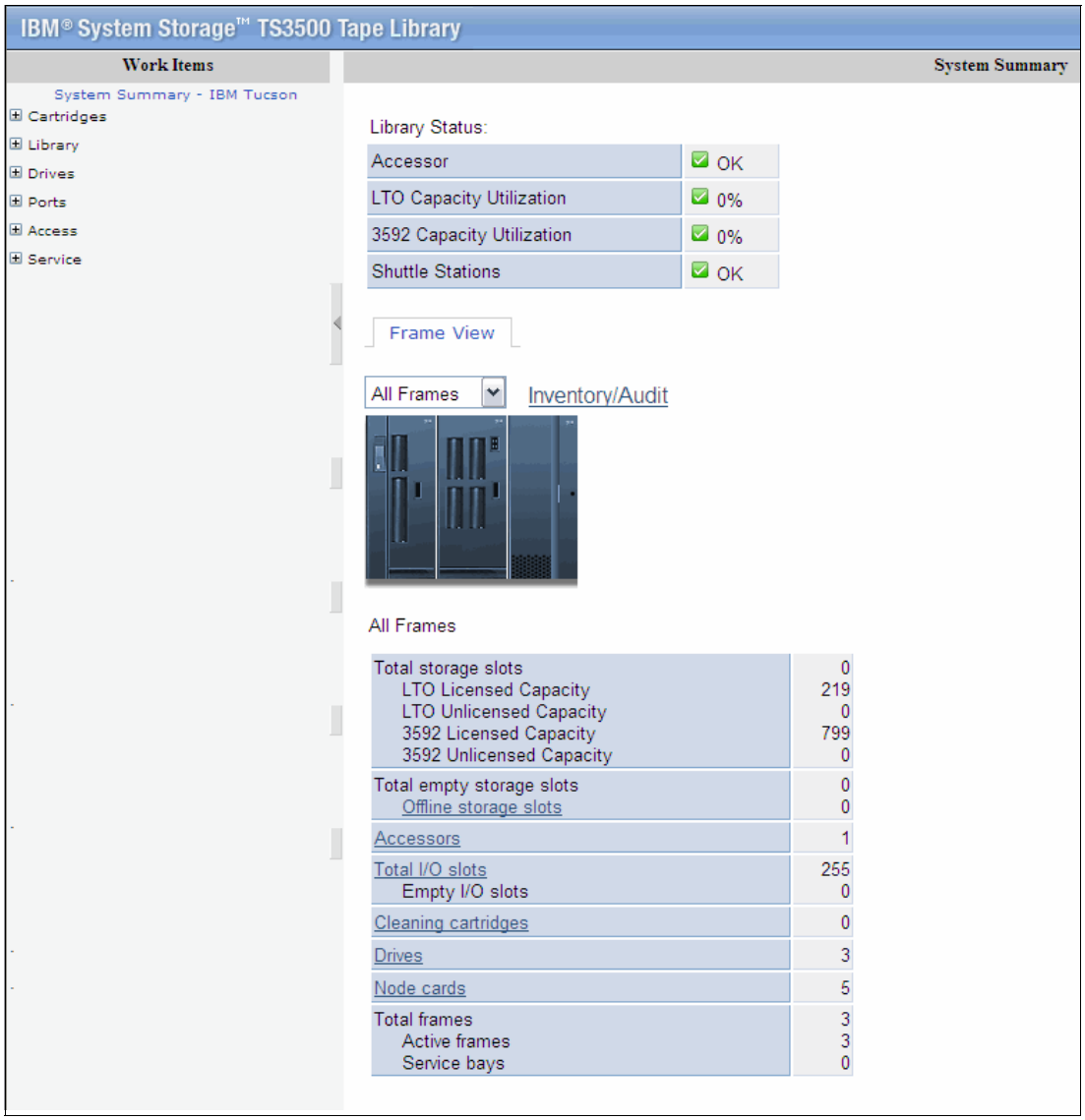


Figure 10-28 TS3500 tape library MI System Summary

Important: Depending on the firmware version and frame models of the TS3500 tape library, some options might appear as they do in Figure 10-28.

10.3.1 Reliability

The TS3500 tape library offers high availability and reliability. Most essential components are redundant. (These components were described in 10.2, “Library components” on page 322.) The TS3500 tape library includes the following high-availability features and components:

- Redundant grippers

  A failure of one gripper causes the library to switch to a second gripper.

- Redundant accessors (Optional):
  - A second library accessor operates simultaneously with the first accessor to service mount requests.
  - They non-disruptively fail over to a redundant accessor when any component of either accessor fails.

- Redundant library and drive power

  A single frame library contains one redundant power supply in the Enhanced Frame Controller, which provides power to the library robotics and the tape drives. The power requirements are distributed evenly over both power supplies under normal operating conditions, failing over to a single power supply if required.

- Redundant control and data paths:
  - Any LTO drive can be used as a library control path.
  - Automatic Control Path Failover is available for AIX, Solaris, Red Hat and SUSE Linux, Windows, and HP-UX.
  - Data Path Failover is available for AIX, HP-UX, Red Hat and SUSE Linux, Solaris, and Windows.

- Redundant copies of vital library data:
  - The data includes configuration data, calibration data, and setup data.
  - One node card contains the primary copy. Another node card contains a backup copy.
  - The backup and restore process is automated.

- Redundant copies of library firmware:
  - Each node card contains the firmware for every other processor card.
  - Component replacement is simplified.
  - Each node card contains two copies of operational firmware.
  - It protects the library from potentially harmful firmware update disruptions.
  - It helps reduce the risk of memory failures.

- Closed loop servo systems:
  - These systems include horizontal motion, vertical motion, pivot motion, gripper extend, and retract motion.
  - Each servo system uses feedback.
  - Velocity and position are monitored.
  - These systems allow higher performance (as shown in Table 10-8 on page 345), and knowing the velocity and position allows greater control.
  - Closed loop is more reliable.
  - Collisions and gripper damage can be avoided by monitoring position and velocity.

10.3.2 Remote support

Optional remote support is available for the TS3500 tape library through its Call Home capability. The Call Home feature uses a modem connection and a master console to report failures that are detected by the library or a tape drive. Whenever a failure is detected, Call Home sends detailed error information to an IBM Support Center. Qualified Support Specialists analyze the Call Home data and decide whether an action is required as a result of that Call Home data. The library also might periodically send support information (such as configuration, library and drive code versions, and error logs) to IBM.

The Call Home feature of the TS3500 tape library has the following different, but related, capabilities:

- Problem Call Home

  If the TS3500 tape library or one of its drives detects a problem, the library performs a Call Home operation to create a Problem Management Record (PMR) in the IBM RETAIN system. The information is transferred to IBM for analysis of the problem.

- Heartbeat Call Home

  On a scheduled basis (once a week or one hour after a code update is completed), the TS3500 tape library sends home (to IBM) the following files:

  – A Machine Reported Product Data (MRPD) file
  – A library error log file
  – A drive error log file

  The MRPD file contains information about the machine (library). This information includes the number of frames and drives, the model and serial number of each frame, the type and serial number of each drive, and the code version of the library and each drive. It also includes any machine-detectable features, such as other I/O stations and capacity expansion.

Remote support through a modem

Optional remote support is available for the TS3500 tape library through its Call Home capability through a no-charge feature (FC2710), which permits a single tape library with Call Home capability to have remote support, as described in 10.3.2, “Remote support” on page 338.

Remote support through the IBM TS3000 System Console

IBM TS3000 System Console (TSSC) is a service tool that provides many service and support functions from a centralized location. These functions include error initiated problem reporting, remote services including remote monitoring support, and wellness checking, which are beneficial to the user and the Service Representative.

TSSC includes the following main benefits:

- Remote support enablement
- Reduced telephone line charges
- Faster data offload via broadband call home through Electronic Customer Care (ECC)
- Reduced repair costs
- Improved serviceability
- Better proactive maintenance

IBM TSSC can provide remote support for as many as 24 Removable Media Storage System (RMSS) product frames, or 43 unique attached tape systems.

The TS3500 tape library includes the following remote support capabilities:

- Call Home problem reporting capability with staged, error-specific data gathering for support.
- Ability to defer certain types of Call Home activity to specific business hours.
- Automatic archival of log files for most attached tape systems for subsequent support reference.
- Connectivity to RETAIN.
- Housing service Information Centers for service representative.

TSSC provides the focal point for local service activities within the data center. The TSSC is attached via 100 Mbps private Ethernet network to each RMSS frame or tape system, which allows for many service functions to be performed at the console. The TSSC provides the following local service configuration tools and applications:

- Ability to telnet to multiple tape systems and simultaneously perform multiple service tasks from the TSSC.
- Graphic user interface for tape system and tape drive service diagnostic utilities.
- Ability to broadcast control unit and tape drive code images to tape systems for subsequent activation from the TSSC.
- Diagnostic tools for verifying communications with attached systems.
- Graphical interface for monitoring the health of the systems, managing the firewall rules of the TSSC, configuring call home rules and settings, and using network tools.

FC2722 provides the enhanced rack-mountable TSSC, an Ethernet switch, and a cable and connectors for connection of one machine to an IBM supplied modem to enable remote enhanced service. Feature FC2732 provides a 1-U server, keyboard, display, mouse, and Ethernet switch. TSSC includes a console upgrade previously provided as feature FC2719 (memory upgrade to 2 GB total RAM and a second Ethernet card).

Figure 10-29 shows the rack-mountable TSSC.

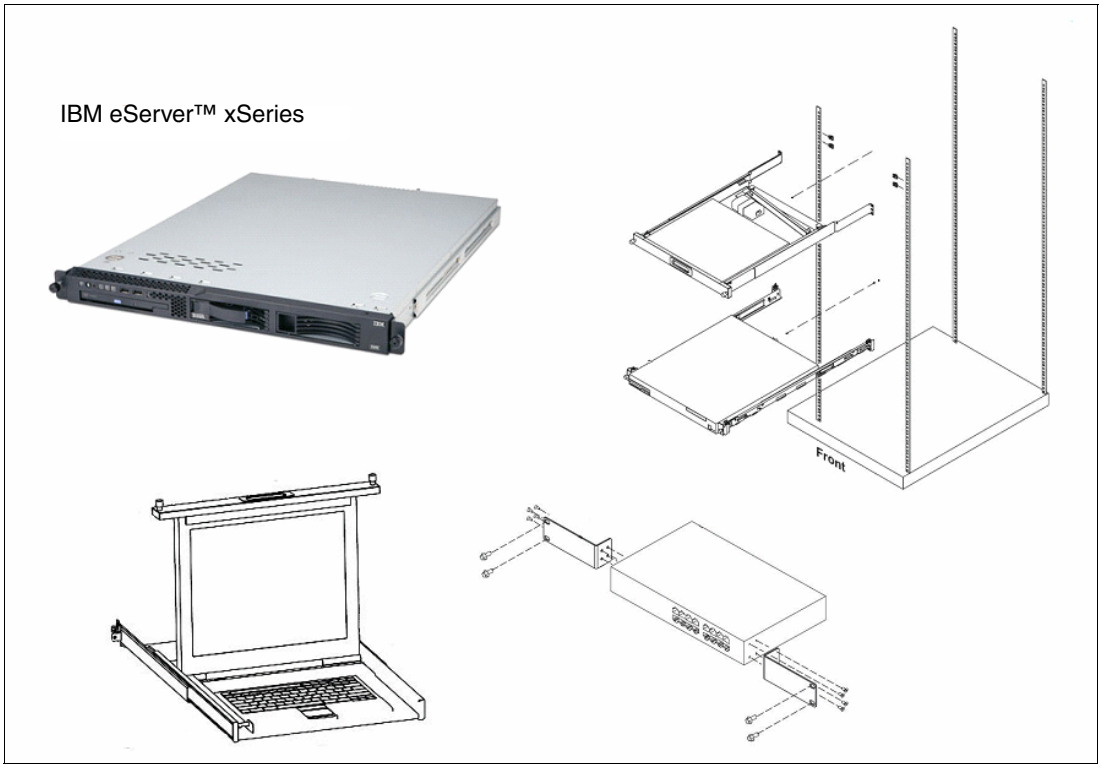


Figure 10-29 Rack-mountable TSSC system console

To perform an ECC Call Home operation through a system console, the TS3500 tape library sends Call Home information across a private Ethernet connection to the system console. The system console then performs the ECC Call Home operation and sends the information to IBM RETAIN across a private Ethernet network to the master console. The master console then performs the Call Home operation by one of the following methods:

- Using a modem and analog telephone line.
- Using Ethernet and a VPN connection through the user network.

Call Home through modem

After the data is collected by the TSSC, it sends the information to IBM RETAIN through the modem connection of the TSSC. Figure 10-30 shows the flow of data in a configuration in which a single Master Console is supporting multiple Call Home-capable tape libraries.

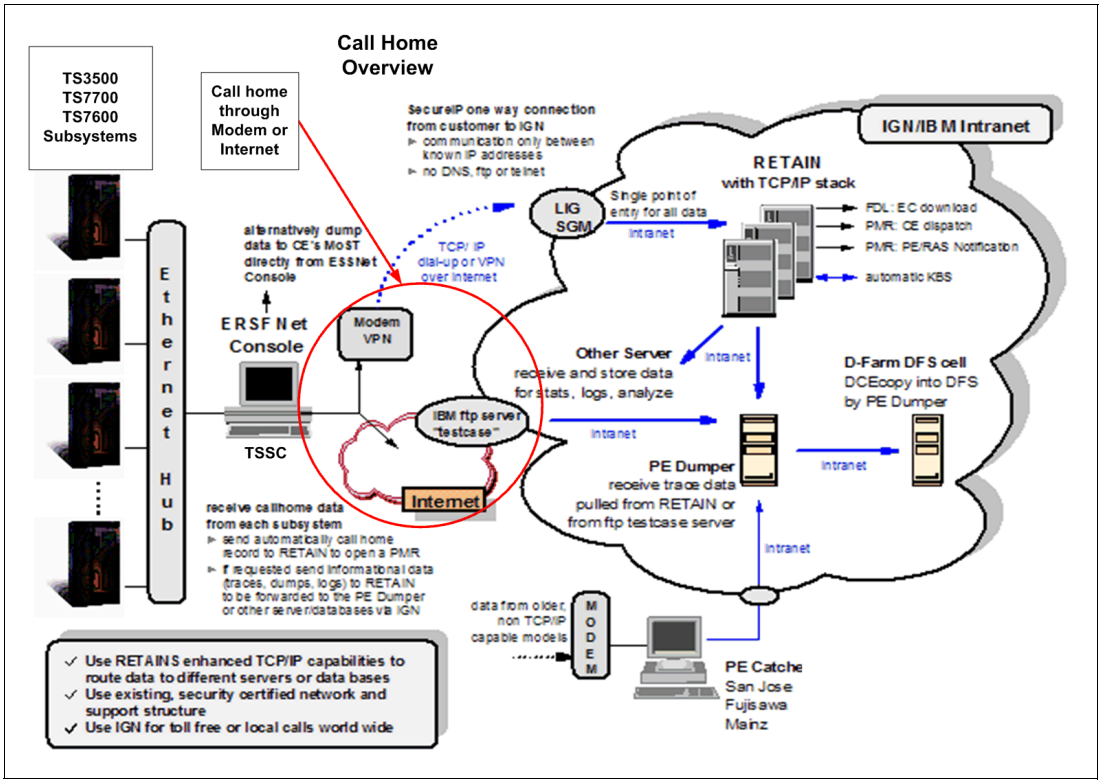


Figure 10-30 Flow of data from a master console supporting multiple libraries

Call Home over Internet

After the data is collected by the TSSC, it sends the information to IBM RETAIN over an outbound Ethernet connection to the user network (see Figure 10-30).

All outbound traffic is limited to HTTP, HTTPS, and DNS information. All service-related data is communicated by using HTTPS and, therefore, is encrypted. The data that is exchanged between the attached systems and RETAIN is service-related data. The protocol that is used is specific to this application and not publicly available.

Important: The TS3000 system console uses the following ports: HTTPS: Port 443, HTTP: Port 80, and DNS: Port 53. The network firewall must be configured to allow for network traffic from the TSSC that is using these ports.

On the first data exchange of each transmission, RETAIN validates that the calling system is entitled to service. If the calling system is not validated, it is disconnected.

For remote support through a system console, the TS3500 tape library needs a minimum of two Ethernet ports: one attached to the network for use by the administrator and one attached to the private system console network for remote support. New frame models L23 and L53 provide two Ethernet ports per frame so no other features are necessary. Frame models L22, L32, and L52 require an Lx3 model conversion or the enhanced node card feature (FC 1700) to support the dual Ethernet port requirement. The library feature code 9217 provides an Ethernet cable for the remote support connection from the TS3500 tape library to a system console.

Important: When the TS3500 tape library is in an environment that includes a system console, IBM recommends that the library perform the Electronic Customer Care (ECC) Call Home function through the system console instead of through a direct modem connection.

10.3.3 Monitor and report

The following TS3500 tape library facilities are available:

- SNMP
- Storage Management Initiative Specification (SMI-S)
- IBM System Storage Productivity Center
- Lightweight Directory Access Protocol (LDAP) support
- Command-line interface (CLI)

SNMP

Occasionally, the TS3500 tape library might encounter a situation that must be reported, such as an open door that causes the library to stop. Because many servers can attach to the TS3500 tape library by different attachment methods, the library provides a standard TCP/IP protocol called Simple Network Management Protocol (SNMP). SNMP sends alerts about conditions (such as an opened door) over a TCP/IP LAN network to an SNMP monitoring server.

These alerts are called *SNMP traps*. By using the information that is supplied in each SNMP trap, the monitoring server (with the client-supplied software) can alert operations staff about possible problems or operator interventions that occur. Many monitoring servers (such as IBM Tivoli NetView®) can be used to send email or pager notifications when they receive an SNMP alert.

The monitoring server must be loaded with Systems Management software that can receive and process the trap, or the trap is discarded. SNMP trap support does not provide a mechanism for the operator to gather more information about a problem or to query the library about its status.

If the Systems Management software includes an SNMP compiler, interpretation of SNMP traps might not be needed, but the Management Information Base (MIB) of the library is required. The MIB contains units of information that specifically describe an aspect of a system, such as the system name, hardware number, or communications configuration.

For more information about interpreting an SNMP trap or the use of SNMP MIBs to monitor the TS3500 library, see *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0560.

SMI-S support

The SMI-S is a design specification of the Storage Management Initiative (SMI) that was started by the Storage Networking Industry Association (SNIA). The SMI-S specifies a secure and reliable interface that allows storage management systems to identify, classify, monitor, and control physical and logical resources in a SAN.

The SMI-S Agent is the IBM implementation of the Common Information Model (CIM). The CIM is an interface standard in the enterprise storage network environment that enables interoperability for hardware and software products that might come from different manufacturers. The CIM provides common protocols and data models that storage product manufacturers can use to ensure ease of use and manageability of the storage network environment.

An embedded SMI-S agent is no longer provided with, or supported by, the TS3500 tape library. However, it is still possible to use a proxy SMI-S Agent for Tape on a separate Linux machine or to enable SNMP messaging as an alternative to SMI-S.

The TS3500 tape library also provides detailed information about activity during the last 24 hours in four files that can be downloaded by using the web UI. For more information, see 12.4, “Preferred practices” on page 439.

System Storage Productivity Center

The IBM System Storage Productivity Center is a suite of storage infrastructure management tools. These tools can help reduce the complexity of managing the storage environments. They simplify and automate storage tasks that are associated with storage systems, storage networks, replication services, and capacity management.

System Storage Productivity Center supports the TS3500 tape library. System Storage Productivity Center centralizes the management of complex and heterogeneous storage environments, including IBM enterprise storage systems and vendor-acquired storage systems. System Storage Productivity Center provides a graphical user interface and utilities to configure these devices and enhancements to provide a broader set of management functions.

For the TS3500 tape library, the System Storage Productivity Center has the following features:

- System Storage Productivity Center TapeManager displays the physical entities of the TS3500 tape library.
- The TS3500 tape library CIM Agent is embedded, and no extra CIM Agent is needed.
- The single sign-on (SSO) feature requires a centralized user and group repository, such as an LDAP-compliant directory, that all participating applications can access.

The System Storage Productivity Center offers the following support:

- Helps centralize the management of storage infrastructure from a single interface by using role-based administration and SSO.
- Provides a single management application with modular integrated components that are easy to install. Also provides common services for simple, consistent configuration and consistent operations across host, fabric, and storage systems.
- Manages performance and connectivity from the host file system to the physical disk, including in-depth performance monitoring and analysis of SAN fabric performance.
- Manages the capacity use and availability of storage systems, file systems, and databases.
- Monitors, manages, and controls (zone) SAN fabric components.
- Automates capacity provisioning of file systems.
- Monitors and tracks the performance of SAN-attached SMI-S compliant storage devices.

- Manages advanced replication services (Global Mirror, Metro Mirror, and FlashCopy) on disk systems.
- The System Storage Productivity Center can help perform the following tasks:
- Manage the capacity use of storage systems, file systems, and databases.
- Automate file system capacity provisioning.
- Perform device configuration and management of multiple devices from a single user interface.
- Tune and proactively manage the performance of storage devices on the SAN.
- Manage, monitor, and control the SAN fabric.

System Storage Productivity Center is a single integrated solution to help improve storage management and performance. It combines the assets, capacity, performance, and operational management that are traditionally offered by separate Storage Resource Management, SAN Management, and Device Management applications into a single platform.

For more information about how to install, configure, and use IBM System Storage Productivity Center, see the following publications:

- *IBM System Storage Productivity Center Introduction and Planning Guide*, SC23-8824
- *IBM System Storage Productivity Center Documentation CD*, SCD7-1477
- *Read This First: Installing the IBM System Storage Productivity Center*, GI11-8938
- *IBM System Storage Productivity Center User's Guide*, SC27-2336

These publications are available in the IBM Publication Center at this website:

https://www.ibm.com/jct05001c/e-business/linkweb/publications/servlet/pbi.wss

Lightweight Directory Access Protocol support

LDAP is the industry standard Internet Protocol that provides centralized user account management. By enabling LDAP, existing user accounts that are on an LDAP server can be integrated into the account management subsystem of the library for the current user. User account information is centralized and shared by different applications, which simplifies user account management tasks.

The library supports the Microsoft Active Directory LDAP server. Windows Services for UNIX 2.5 is required for this support. User password schemes must be encrypted by using UNIX cryptography. In addition, user names (*uid*) and passwords (user *password*) must be created by using lowercase characters to be compatible with the library.

For LDAP users with user privileges, access to the logical libraries of the library is determined by group assignment on the LDAP server. Groups must be created on the LDAP server with names that correspond to the logical library names of the library. Users with user privileges must be assigned to these groups on the LDAP server to have access to the corresponding logical libraries on the library. LDAP users with administrative privileges have access to all logical libraries and administrative functions and do not need to be assigned to logical library-related groups on the LDAP server.

Command-line interface

The TS3500 tape library CLI (program) can be used to access the TS3500 tape library from a CLI. This program is in addition to the TS3500 Tape Library Web Specialist User Interface. The TS3500 tape library CLI is oriented to the open system platforms.

For more information about the TS3500 tape library CLI, see 12.2.3, "Command-line interface" on page 427, and the TS3500 tape library Command Line Interface website at:

http://www.ibm.com/support/docview.wss?uid=ssg1S4000854&myns=s034&mynp=familyind5329831&mync=E

10.3.4 Adding and removing cartridges

Cartridges can be inserted into the TS3500 tape library by using one of two methods.

The first method is to insert cartridges through the I/O station (see Figure 10-2 on page 294) on the front door of the L*xx* frame of the TS3500 tape library. With this method, cartridges can be inserted or removed from the library enclosure without interrupting library operation. The I/O station is controlled by the host application software that uses the library or from the operator panel. Insertion of cartridges into the I/O station alerts the application software, which registers the other cartridges and their status in its database and instructs the accessor to move the new cartridges into library slots. The slot location of each cartridge is held in the host application software database. For more information about how to insert cartridges, see *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0560.

The second method to insert cartridges is to open the front door of a frame and bulk load the cartridges directly into empty storage slots. When the door is closed, the library performs a cartridge inventory operation, which determines whether each cartridge storage slot in the frame is empty or full and scans the cartridge bar code labels. When the library performs an automatic inventory in this way, the inventory occurs only for those frames whose doors were opened.

Attention: It can take up to 60 seconds per frame for cartridge inventory.

Removal of data cartridges can be performed by using host application software and through the tape library Specialist or the operator panel. For more information about how to remove cartridges, see *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0560.

10.4 Performance

The performance capability of a tape library solution depends on the individual bandwidth capability of the drives and data bus and the speed of the robotic handling. The degree of importance for each of these elements depends on the quantity of the data that is transferred during one operation. For example, when large files (larger than 800 MB) are red or written to tape, the data rate of the tape drive is the overriding contributor to the speed of the operation. However, for reading or writing many small files (25 MB or less) to different tapes, the cartridge move and load times become the overriding contributor.

10.4.1 Elements that contribute to high-performance capabilities

Many elements contribute to high performance, as described in the following sections.

Library bandwidth

The bandwidth of the TS3500 tape library that is shown in Table 10-7 on page 345 relates to the drive performance that is described 2.3.2, “LTO performance” on page 73. Compressed drive performance can be calculated by assuming a compression ratio of 2:1 for LTO tape drives.

Table 10-7 TS3500 tape library bandwidth

Tape drives	LTO Ultrium 4 native	LTO Ultrium 5 native	LTO Ultrium 6 native	TS1130 native	TS1140 native	TS1150 native
72	31.1 TB/hr.	36.3 TB/hr.	41.5 TB/hr.	42.2 TB/hr.	64.8TB/hr.	93.3 TB/hr.
192	82.9 TB/hr.	96.8 TB/hr.	110.6 TB/hr.	110.6 TB/hr.	172.8 TB/hr.	248.8 TB/hr.

Cartridge move time

Move time is the time that is required for the cartridge accessor to pick a cartridge from a random slot, move the cartridge to a drive, pivot (if required), and insert the cartridge into the drive. In a single-frame TS3500 tape library, the typical time to move a cartridge from a cartridge storage slot to a tape drive, for example, is less than 2.7 seconds. For a six-frame configuration, this rate increases only to 3.8 seconds. For the maximum 16 frames, the average move time is still only 6.2 seconds, as shown in Table 10-8. For maximum performance, as demonstrated in Table 10-8, drives must be centrally located and as close together as possible. The table does not apply to libraries that contain dual accessors.

Table 10-8 Library performance without dual accessor

Library configuration	Average move times with all drives in frame 1	Average move times with all drives in a central frame
One frame	2.7 seconds	
Two frames	2.6 seconds	
Four frames	3.3 seconds	2.9 seconds
Six frames	3.8 seconds	3.3 seconds
Eight frames	4.4 seconds	3.7 seconds
Twelve frames	5.3 seconds	4.3 seconds
Sixteen frames	6.2 seconds	4.7 seconds

Mount throughput

Mount throughput is a measure of the overall capability of the cartridge accessor and tape drives. It is the number of cartridges that the tape library can mount in one hour. A *mount* is often called the *mount/demount cycle*. It involves removing the cartridge from a drive, returning it to its storage slot, collecting another cartridge from a random storage slot, moving it to the drive, and loading the cartridge into the drive.

Table 10-9 shows the mount throughput performance for the UltraScalable tape library with and without dual accessors. The table demonstrates that, to maximize performance with dual accessors, each accessor must have drives centrally in its preferred zone.

Table 10-9 Library mount throughput

Library configuration	Without dual accessor		With dual accessor	
	Mounts per hour with all drives in frame 1	Mounts per hour with all drives in a central frame	Mounts per hour with all drives in frame 1	Mounts per hour with all drives in a central frame
One frame	550			
Two frames	520			

Library configuration	Without dual accessor		With dual accessor	
	Mounts per hour with all drives in frame 1	Mounts per hour with all drives in a central frame	Mounts per hour with all drives in frame 1	Mounts per hour with all drives in a central frame
Four frames	410	430		1000
Six frames	350	380		900
Eight frames	310	350		800
Twelve frames	255	300		700
Sixteen frames	215	260		600

Important: The dual accessor mount throughput assumes that the library is partitioned into at least two logical libraries so that each of the cartridges in the two zones is mounted in drives within each zone with no accessor path overlap.

Library inventory time

During normal use of the TS3500 tape library for bulk loading of cartridges, the library performs an inventory operation to check the (possibly new) content of the cartridge storage slots. During this time, the accessor is occupied by scanning the bar code labels and empty slots. The inventory process for the TS3500 tape library is performed efficiently, usually taking fewer than 60 seconds per frame. For more information about inventory performance, see "Performing an inventory" on page 303.

10.5 Upgrades and optional features

The TS3500 tape library has a number of optional features. These features enhance the library by providing extra functions, more capacity, higher reliability, and greater serviceability.

For more information about available features, see the sales manual for the TS3500 tape library at this website:

http://www.ibm.com/common/ssi/index.wss

10.6 Advanced Library Management System

The Advanced Library Management System (ALMS) provides enhanced flexibility and capabilities for partitioning the TS3500 tape library. ALMS virtualizes the SCSI element addresses while maintaining the approach of the multipath architecture and the use of SCSI-3 Medium Changer commands. Without ALMS, everything is based on the SCSI element address (location-centric), and partitioning is based on real cartridge slots and drive slots. With ALMS, there is no affinity between a real slot address and a SCSI element address that is reported to the server and used by the server. Instead, there is now an affinity with the VOLSER (on the bar code label of the cartridge).

ALMS eliminates downtime when Capacity-on-Demand storage is added, logical libraries are added or removed, or logical library storage allocation is altered. ALMS also reduces downtime when expansion frames are added, tape drives are added or removed, or logical drive allocation is changed.

ALMS offers the following capabilities on the TS3500 tape library:

- Dynamic partitioning:
  - Storage slot pooling
  - Flexible drive assignment
- Add and remove physical storage capacity that is not apparent to any host application
- Configure drives or L*xx* storage capacity without taking the library offline
- Virtualize I/O slots to automatically manage the movement of cartridges between I/O station slots and storage slots

The TS3500 tape library is compliant with the SCSI Medium Changer standard regardless of whether ALMS is enabled. When it is enabled, ALMS is not apparent to the application. The SCSI Medium Changer can be thought of as a “location-centric” interface. The application that is controlling a SCSI Medium Changer device specifies a source and destination location for each request to move a cartridge. The traditional SCSI library does not have control of the cartridge locations. Instead, the SCSI library acts on behalf of the server.

The following ALMS feature codes can be used to purchase the ALMS, depending on the capacity of the installed L*xx* frame:

- Entry ALMS (FC1692) can be purchased for an entry-capacity L*xx* frame.
- Intermediate ALMS (FC1693, which has a prerequisite of FC1692) can be purchased for an intermediate-capacity L*xx* frame.
- Full ALMS (FC1694, which has a prerequisite of FC1693) can be purchased for a full-capacity L*xx* frame.
- ALMS (FC1690) can be purchased for any capacity of L*xx* frames.

For more information about L*xx* frame capacity, see 10.1.2, “TS3500 tape library frames L23 and D23” on page 297.

One of the previously listed ALMS feature codes is needed if the following components are required:

- Dual active accessor libraries (requires FC9040)
- System z attachment (requires FC9217)
- High Density frame (HD)

Restriction: ALMS for the TS3500 tape library and requires FC1690, FC1692, FC1693, or FC1694 for enablement.

10.6.1 Functional description

This section provides a functional description of the ALMS features.

Storage slot virtualization

The host view of a cartridge location is known as the *SCSI storage element address*. Without ALMS, the storage element address maps directly to a specific storage slot after the library is configured. With ALMS enabled, a given storage element address is no longer associated with a specific storage slot. Instead, storage slots are virtualized by dynamically associating them with element addresses, as required. An element address is associated with a storage slot that is selected by the library, as cartridges are moved and inventoried. If a storage element is empty because of a move, that source element address becomes unassociated. Association of storage element addresses is accomplished in a way that is not apparent to the application software.

The number of storage element addresses can be selected for a logical library (as reported to the host application software) by changing the Maximum Number of Cartridges setting for that logical library with the web UI (tape library Specialist). For each logical library, the default value for this setting is the number of addressable storage slots that are installed in the library for that cartridge type when ALMS is first enabled or, after ALMS is enabled, when the logical library is created.

The Maximum Number of Cartridges setting can be changed for each logical library, but the value must always be greater than or equal to the number of cartridges that are currently assigned to that logical library. The Maximum Number of Cartridges can be set to a value higher than the number of addressable storage slots that are installed at the time to allow future library capacity expansion to be not apparent to the host application software. However, application performance might degrade slightly because of the greater number of addresses. Care should be taken to not exceed the license limitations of the host application software.

The starting element address for storage slots of each logical library is x'400' (1024) plus the associated logical library number. For example, logical library 1 starts at x'401' (1025), logical library 2 starts at x'402', and so on (see Figure 10-31 on page 349). The reason that they do not all start at x'401' is because certain applications must be able to differentiate between different logical libraries from the same physical library.

Drive assignment

By using the ALMS flexible drive assignment capability, any drive in any position within any frame can be assigned to any logical library without creating any gaps in drive addresses. Drive (data transfer) element addresses are still mapped to specific drive locations when the drive is assigned. However, any drive location now can be assigned to any logical library (intermix supported) by using the tape library Specialist. Each drive that is added to a logical library is assigned to the lowest available element address, regardless of drive location.

When ALMS is first enabled, the Data Transfer Element (DTE) addresses of all installed and assigned drives are not changed from their previous values. However, after ALMS is enabled, the DTE addresses for any newly installed and assigned drives no longer depend on the position of the drive. Instead, the DTE address for any newly installed or assigned drive is determined by the sequence in which the drive is assigned to each logical library. After ALMS is enabled, drives are assigned to logical libraries by using the Drive Assignment page of the tape library Specialist.

With this interface, the DTE address for the first drive that are assigned to a new logical library is 257 (x'101'), as shown in Figure 10-31 on page 349. The DTE address for any other drive that is assigned to a logical library is based on the next available DTE address in that particular logical library. The next available DTE address is the lowest-available DTE address after the starting DTE address. (This address fills any gaps that are created when drives are unassigned and removed from a logical library.) When a drive is unassigned from a logical library by using the web interface, only that DTE address is made available for future use. No other DTE addresses are affected.

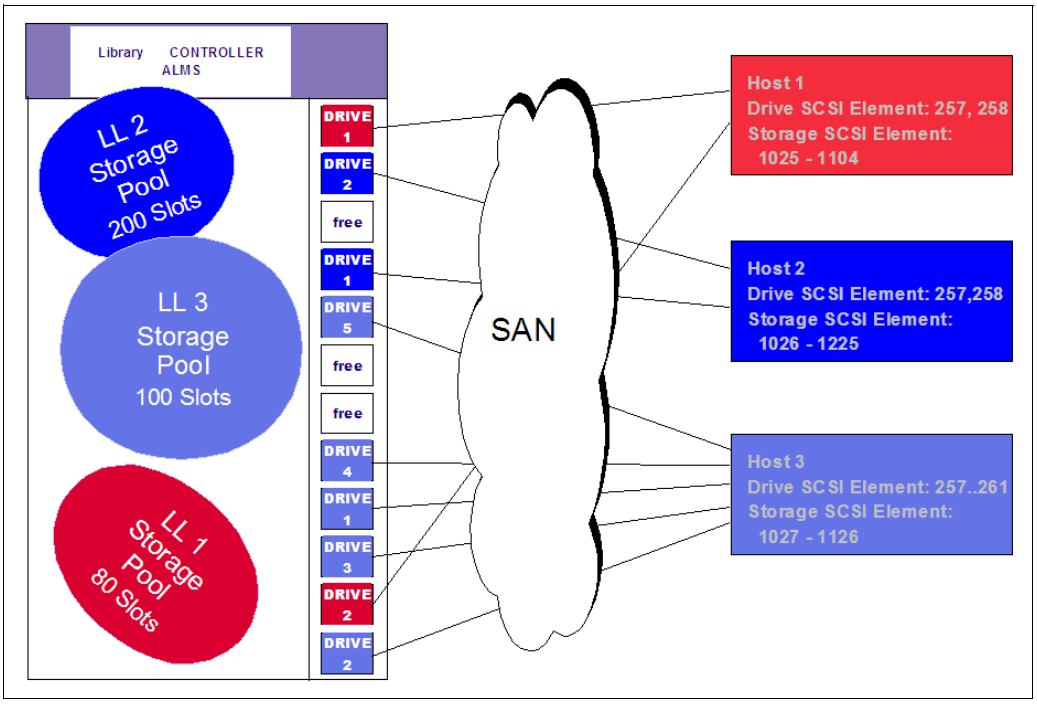


Figure 10-31 TS3500 tape library with ALMS

The Drive Assignment page also supports the option to share a drive between two or more logical libraries. The drive is assigned a DTE address in more than one logical library. The DTE addresses that are assigned to a shared drive might differ by logical library.

By using the ALMS dynamic Drive Assignment capability, any drive in any position in any frame can be assigned to any logical library without creating gaps in DTE addresses.

Storage slot pooling

With ALMS, logical libraries can be added or deleted concurrently. All storage slots are managed on a first-come, first-served basis to each logical library based on cartridge insert operations. Therefore, storage slots are pooled as a shared resource. This way, changes to the capacity allocation for each logical library can occur without any downtime or administrator involvement to the logical library not changing. Indications of a full or nearly full physical library continue to be provided by the operator panel, Tape Library Specialist, and SNMP traps.

The logical library has a name, and can be thought of as a file folder with no content. Drives can be placed in the file folder by using the Drive Assignment panel of the Tape Library Specialist. Cartridges also can be placed in the file folder based on their VOLSER numbers and by using one of the following methods (in order of priority):

1. Migration from static partitioning (ALMS Disabled) to enabling ALMS by using the Management Interface (MI).
2. Cartridge Assignment Policy (allocation is done automatically at the time of insertion based on the set policy).
3. Insert Notification (operator panel selection at time of insertion).
4. Software application move from I/O station (based on source of command).
5. Manual assignment by using the Tape Library Specialist.

The VOLSER assignment and physical location of cartridges are stored in non-volatile RAM (both primary and backup copies).

Shared drive assignment

Certain clients require the ability to easily share a drive on an exception basis. For example, a drive might be required for a once-a-month job or as a temporary replacement for a failed drive. The Tape Library Specialist drive assignment UI supports the ability to assign a drive to multiple logical libraries. Therefore, each logical library consists of dedicated drives and shared drives. Each logical library maps a drive element address to the location of dedicated and shared drives.

Important: Any drive with control path enabled cannot be shared.

This option reduces the requirement to configure and unconfigure the tape drive every time, regardless of whether it is needed.

The Drive Assignment web window supports the following point-and-click capabilities, which are nondisruptive to other logical libraries:

- Assign the drive
- Remove the drive assignment
- Reassign the drive

When a cartridge is mounted in a shared drive, the library only accepts an unmount command requested from the source logical library. Any unmount command that is requested from other logical libraries is rejected.

However, the data path to the tape drive is not protected by the library. Therefore, the administrator must ensure that shared drives are not accessed by the wrong application from the data path. One option to ensure that shared drives are not accessed by the wrong application from the data path is to use the SCSI reserve and release option on open and close. The device driver together with the application handles this option. On a device open, the application initiates a SCSI reserve through the tape device driver. No other server can access the tape drive (except for commands, such as inquiry), which ensures that data is not overwritten by any other host or application. After the device is closed, the application must send a SCSI release to the tape drive. Most applications handle this option, but it is best to check with the backup software provider to confirm.

SAN zoning can be used to prevent access to the same tape drives by different servers.

When a tape drive is shared by applications, any application that uses the drive is unaware of the other applications sharing the tape drive. Therefore, a cartridge might be loaded already and in use by application A. However, if application B does not know it and tries to mount a cartridge in the same drive, application B receives a failure and the job that application B was running fails. Several applications periodically scan all the tape drives. If they recognize that a cartridge is mounted without initiation from the application, the application considers this tape drive offline.

In any case, do not allow multiple applications to use shared tape drives concurrently. Set tape drives offline (or in service mode) from the application whenever they are not in use by that application.

The sharing option is intended for environments where certain drives are needed only occasionally and must be preconfigured for the application.

Important: An application that occasionally leaves cartridges in drives or periodically scans all configured drives is not a good candidate for sharing drives between logical libraries.

Cartridge Assignment Policy

With the Cartridge Assignment Policy (CAP) feature of the TS3500 tape library, cartridge VOLSER numbers can be assigned to specific logical libraries through the Tape Library Specialist MI. When a cartridge is inserted into the I/O station, the CAP is used to associate the cartridge with a logical library. If the cartridge is not in the CAP and Insert Notification (see "Insert Notification" on page 351) is enabled, the cartridge can be assigned to a logical library by using the Insert Notification process on the operator panel library. Alternatively, the cartridge can be kept as unassigned and assign it later by using the MI. If the Insert Notification feature is not enabled and the cartridge was not in the CAP, the cartridge eventually is available to all hosts.

The CAP is media type-specific. It is based on the six most significant characters of the cartridge label. The ranges of VOLSERs do not include the media-type indicator (L3, L4, JA, JJ, and so on). Therefore, two identical labels (except for the media type indicator) can be assigned to two different logical libraries; for example, libraries that contain LTO or 3592 drives.

Reassigning a cartridge: The Cartridge Assignment Policy does not reassign an assigned tape cartridge. To reassign a cartridge, use the procedure for assigning cartridges to a logical library.

Insert Notification

Insert Notification is an option that enables TS3500 tape library to monitor the I/O station for any new media that does not have a logical library assignment. This feature can be enabled through the operator panel or the Tape Library Specialist. With Insert Notification enabled, when new media is detected, the operator panel shows a message that prompts selection of a logical library. Any unassigned cartridges in the I/O station are assigned to the logical library that is selected (all other logical libraries are unable to access the cartridges). The library includes an option to defer any assignment, and there is a timeout period when the deferral automatically takes effect.

Important: When one or more 4-I/O station doors are installed, the Insert Notification cannot be enabled.

10.6.2 Virtual I/O

The TS3500 tape library has I/O stations and I/O slots that allow the importing and exporting of up to 32 cartridges at any given time. The I/O slots are also known as *import/export elements (IEEs)*. Virtual I/O (VIO) slots increase the quantity of available I/O slots by allowing storage slots to be displayed to the host application as I/O slots. The goal of virtual I/O slots is to reduce the dependencies between the system administrator and library operator. This way, each person performs their import and export tasks without needing the other person to perform any actions. With virtual I/O slots, the library automatically moves cartridges from the I/O stations to physical storage slots and from physical storage slots to the I/O stations.

With virtual I/O slots, up to 255 VIEEs can be configured per logical library. Each logical library has a unique VIEE address space that is not accessible by other logical libraries. By default, new logical libraries are assigned the maximum number of virtual I/O slots. Logical

libraries that were defined (before ALMS is enabled) initially have the number of physical I/O slots in the library.

Before virtual I/O slots, the IEE space consisted of physical I/O station slots (10, 30, 16, or 32 depending on the frame model type) that were shared by all logical libraries. If the application or system administrator did not explicitly import the cartridges from the I/O station into library storage, the cartridges remained in the I/O station, which reduced the number of IEEs to process imports and exports and locked out other shared host applications from using the I/O slots.

With virtual I/O slots, when cartridges are inserted into the I/O station, the library works with the CAP or Insert Notification to assign a cartridge to the correct logical library VIEE space. Cartridges are automatically moved into library storage slots. If no CAP is assigned and Insert Notification is disabled for a particular cartridge, that cartridge is inserted into the VIEE space of all logical libraries and automatically moved into a library storage slot, which frees up the physical I/O slots for other host applications.

Important: While the TS3500 tape library automatically moves cartridges from the I/O slots into the library, the TS3500 tape library VIO firmware assigns these internal slots as I/O element addresses. The host application still is required to perform an insert operation.

The VIEE temporarily takes on the attributes of an IEE until a host moves the cartridge into a storage element (StE). When the host move occurs, if the cartridge is in a storage slot, no physical move is needed and the element changes from a VIEE to an StE. Similarly, when a host exports a cartridge from an StE, the physical storage slot is reported as a VIEE without moving the cartridge to the I/O station. The library monitors when free space is available in the I/O station and moves exported cartridges when it is convenient for the library.

If a cartridge cannot be assigned, this situation is reported as `Assignment Pending`. This situation can occur if the assigned logical library does not have any available VIEE slots, or if all of the logical libraries do not have a common VIEE to share. To resolve this situation, free up VIEE addresses so that they are available in all libraries, or make a specific assignment of this cartridge to a logical library.

VIO has the Hide or Show Exports option. Show Exports, which is the default option, shows a VIEE inventory of cartridges exported from the logical library. These cartridges fill one of the VIEE slots for that logical library. The `Export Complete` status is shown when the exported cartridge is physically in an I/O station slot.

The Hide Exports option moves the exported cartridges to a library-maintained export queue. The VIEE is available immediately for other imports or exports, and the exported cartridge is removed from the inventory data of the host application. Exporting a cartridge is reported as `Export in Progress` if no VIEE is available, and the process does not complete until one is available. With Hide Exports, this situation does not occur.

Support for VIO slots is provided at library Licensed Internal Code level 5360 and after and is enabled, by default, when ALMS is enabled. Existing clients who enabled ALMS on their TS3500 tape library must install a newer level of library Licensed Internal Code that supports VIO and then manually enable the VIO slots.

10.7 Host platforms and device drivers

The TS3500 tape library is supported on many operating systems. For a current list of host software versions and release levels that support the TS3500 tape library, go to the IBM Tape System resource library at this website:

http://www.ibm.com/systems/storage/tape/

10.7.1 Feature codes

The following no-charge feature codes indicate the open systems server platform to which the TS3500 tape library is attached. These features are used by IBM for device driver distribution:

- FC9210: Attached to HP-UX
- FC9211: Attached to Oracle system
- FC9212: Attached to Windows system
- FC9213: Attached to other non-IBM system
- FC9215: Attached to Linux system
- FC9216: Attached to System z Linux system
- FC9218: Attached to HPSS
- FC9400: Attached to System i
- FC9600: Attached to System p

More than one platform-attach feature can be chosen because the library can be attached to more than one of these platforms. More than one of each feature cannot be added. That is, if there are two or more Windows servers that use the TS3500, only one FC9212 is required.

Tip: The device driver is available for each operating system from the Fix central website:

http://www.ibm.com/support/fixcentral/

10.8 Storage applications

Software to use the TS3500 tape library is not provided with the library. Other software support is available through products that must be obtained separately from IBM, IBM Business Partners, or independent software vendors.

Details are available for each application that supports Ultrium and 3592 tape drives and attachment methods. Also, the storage application vendor should be contacted for more information about specific versions and supported platforms. Several examples of third-party software applications with IBM LTO drives and libraries are provided in *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

10.9 Specifications

The TS3500 tape library is a stand-alone tape subsystem that consists of one or more frames and is capable of modular expansion to provide large capacities. The frames join end-to-end with the base frame on the left (viewed from the front) and the expansion frames extending to the right.

10.9.1 Physical specifications

Table 10-10 lists the physical dimensions of the TS3500 tape library frames.

Table 10-10 Physical dimensions

Model	Width	Depth	Height
L32 and D32	72.5 cm (28.5 in.)	152 cm (59.8 in.)	180 cm (70.9 in.)
L23, D23, L53, D53, and HA1	72.5 cm (28.5 in.)	121.2 cm (47.72 in.)	180 cm (70.9 in.)

Table 10-11 lists the weights of the frames according to the number of installed drives, robotics, and tape cartridges.

Table 10-11 TS3500 tape library weight

Model	Weight of base frame with 1 drive and 0 cartridges	Weight of base frame with 12 drives and maximum cartridges
L32	425 kg (937 lb.)	570 kg (1256 lb.)
D32	355 kg (784 lb.)	558 kg (1229 lb.)
L53	366 kg (806 lb.)	526 kg (1160 lb.)
D53	274 kg (604 lb.)	483 kg (1065 lb.)
L23	364 kg (802 lb.)	534 kg (1178 lb.)
D23	270 kg (596 lb.)	494 kg (1089 lb.)
HA1	261 kg (575 lb.)	N/A

Each frame has a set of casters and four leveling jackscrews. The nominal height from the bottom of the jackscrews to the top of the frame is 1840 mm (72.4 in.) and can be varied by ±40 mm (±1.6 in.). The shipping height of the TS3500 tape library (on its casters and with jackscrews raised) is 1800 mm (70.9 in.).

Table 10-12 on page 355 lists the physical specifications (such as height, width, depth, and weight) of the S*xx* models of the TS3500 tape library.

Table 10-12 Physical characteristics of the TS3500 tape library, Model Sxx

Characteristic	S24 frame	S54 frame
Height of frame (on casters)	1800 mm (70.9 in.)	1800 mm (70.9 in.)
Width of frame with cover	782 mm (30.8 in.)	782 mm (30.8 in.)
Width of frame without covers[a]	725 mm (28.5 in.)	725 mm (28.5 in.)
Depth of frame (including front and rear doors)	1212 mm (47.72 in.)	1212 mm (47.72 in.)
Weight of base frame with 0 cartridges	285.8 kg (630 lb.)	290.3 kg (640 lb.)
Weight of frame with maximum cartridges	526.2 kg (1160 lb.)[b]	562.5 kg (1240 lb.)[c]

a. Frame width only. More interframe spacing of 30 mm (1.2 in.) is required.
b. Maximum 1000 3592 tape cartridges. The weight with cartridges assumes a cartridge weight of .242 kg (.534 lb.) for a standard 3592 Tape Cartridge. The weight of the library varies, depending on the configuration and cartridge capacity.
c. Maximum 1320 Ultrium Tape Cartridges. The weight with cartridges assumes a cartridge weight of .206 kg (.454 lb.) for a standard LTO Ultrium Tape Cartridge. The weight of the library varies, depending on the configuration and cartridge capacity.

When you are planning for the installation, the space implications in the computer room should be considered for the possibility of adding more frames in the future.

10.9.2 Floor requirements

The library must be installed on a raised or solid floor. The floor must have a smooth surface and, if raised, must not have ventilation panels beneath the leveling jackscrews. If carpeted, it should be confirmed that the carpet is approved for computer-room applications. To accommodate unevenness in the floor, the leveling jackscrews can be raised or lowered to the following specifications:

- The maximum allowable variance must not exceed 7 mm (0.27 in.) per 76 mm (3 in.).
- The maximum out-of-level condition must not exceed 40 mm (1.6 in.) over the entire length and width of the library.

The floor on which the library is installed must support the following weight specifications:

- Up to 4.8 kilograms per square cm (68.6 lbs. per square inch) of point loads exerted by the leveling jackscrews.
- Up to 211 kilograms per square meter (43.4 lbs. per square foot) of overall floor loading.

The number of point loads exerted depends on the number of frames that make up the library. There are four point loads per frame (at the corners of each frame).

10.9.3 Operating environment

The TS3500 tape library operates in the following environment:

- Temperature: 16–32 C (61–89 F)
- Relative Humidity: 20–80%
- Wet Bulb: 23 C (73.4 F) maximum

10.9.4 Power and cooling specifications

Power and cooling for the TS3500 tape library components are provided by the housing frame. Each base and expansion frame that contains drives has its own frame control assembly, which receives power from a client-supplied outlet and, in turn, provides DC power to all tape drives within the frame. The frame control assembly for the L32, L53, and L23 models contains two DC power supplies. Only one DC power supply is needed to operate the entire library. Before support was provided for 16 frames, all other frame control assemblies in the D frame included one other DC power supply for redundancy. With support for 16 frames, the other frame control assemblies in the D32 no longer have a default-installed DC power supply.

More SDC power supplies can be ordered or made available for extra frames, as described in 10.2.2, “Library control systems” on page 326.

The frame control assembly is not required in expansion frames that do not contain tape drives.

Each frame receives single-phase (200-240 V AC) power on its own power cord from a client-supplied outlet. Certain countries or regions require two-phase power to achieve the 200-240 V AC required by the frame.

A Dual AC Power feature (FC1901), supporting 110 V AC or 220 V AC, is available for the TS3500 tape library, which provides two independent power cords that can be connected to two independent client branch circuits. A power switch connects to one of two client power feeds and passes all AC power to the frame from that feed. The switch monitors the AC line voltage from the feed that it is using and automatically switches to the alternative AC power feed if the incoming voltage drops below a preset level.

Table 10-13 lists the power requirements for the L53 and D53 frames.

Table 10-13 Power requirements for the TS3500 tape library

Power requirements	Types of line cord	
	220 V ac line cord	**110 V ac line cord**
Ac line voltage	200 - 240 V AC (nominal)	100 - 127 V AC (nominal)
Ac line frequency	50 - 60 Hz	50 - 60 Hz
Nominal power	1.4 kW	1.2 kW
Line current	8.0 A	12.0 A
kVA	1.6 kVA	1.2 kVA
Heat output	4.8 kBTU/hr.	4.1 kBTU/hr.
Inrush current	200 A (peak for ½ cycle)	100 A (peak for ½ cycle)

Important: The values that are shown in Table 10-13 are for frames with 12 tape drives installed.

11

IBM TS7600 ProtecTIER Systems

The IBM TS7600 ProtecTIER Deduplication solution meets the disk-based data protection needs of the enterprise data center while enabling significant infrastructure cost reductions. The solution offers high-performance in-line data deduplication, optional two-node clustering, and up to 1 petabyte (PB) of physical storage capacity per system. Combined with IBM storage, the ProtecTIER Gateway solution provides an optimal disk-based target for backup and archive data.

The IBM TS7600 ProtecTIER Deduplication solution can scale to meet the needs of small businesses to an enterprise-class data protection platform. It can quickly and safely protect business information while reducing the amount of space that is required for storage. Customers can experience up to 25:1 storage capacity reduction. Deploying this solution can help organizations more efficiently protect their corporate data on disk-based storage while helping them manage the exponential growth of new data through reduction or elimination of duplicate data in their backups. Starting with ProtecTIER Version 3.2, there is a feature available for order, the File System Interface (FSI). FSI and OST are mentioned briefly in this publication because they differ from tape solutions. Virtual Tape Library (VTL) is described in more detail and ProtecTIER Version 3.3 new functions are highlighted.

The TS7600 solution is designed to perform the following tasks:

- Improve backup and recovery operations without changing existing backup processes, procedures, or policies.
- Shorten the backup window and simplify data management.
- Consolidate heterogeneous tapes and gain control of decentralized open systems data.

This chapter includes the following topics:

- Terminology
- Data deduplication
- TS7650G ProtecTIER Deduplication Gateway
- TS7650 ProtecTIER Deduplication Appliance
- TS7620 ProtecTIER Deduplication SMB Appliance
- ProtecTIER VTL
- ProtecTIER OpenStorage
- ProtecTIER FSI

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- Initial configuration of TS7600
- ProtecTIER Manager
- Set up the virtual library and cartridges
- ProtecTIER SNMP support
- Replication overview
- How it works
- ProtecTIER native replication
- Normal operation concepts
- Many-to-one replication with VTL
- Many-to-many replication with VTL
- ProtecTIER Replication with OST
- ProtecTIER Replication with FSI
- IBM TS3000 System Console
- Operating system

11.1 Terminology

IBM offers three virtualization solutions: TS7650G, TS7650 AP1, and TS7620.

11.1.1 The TS7650G gateway

The terms presented here are for the IBM virtualization solution from the TS7650 family that does not include a disk storage repository, which allows you to choose from various storage options.

The TS7650G consists of the following components:

- 3958 DD5

  This is the latest model that is available from May 2012 and shipped with the ProtecTIER server software version 3.2 or higher. This server is based on the x3850 x5 type 7143 model AC1. When it is ordered as the ProtecTIER TS7650G, the machine type and model are 3958 DD5. Use this machine type and model for service purposes.

- 3958 DD4

  This is a higher performance server than the DD3 and was available from November 2010. This server is based on the x3850 type 7145 server. When ordered as the ProtecTIER TS7650G, the machine type and model are 3958 DD4.

- 3958 DD3

  This is an improved performance server over the previous version and was available since March 2009. This server is based on the IBM System x3850 M2 Type 7233. When it is used as a server in the TS7650G, its machine type and model are 3958 DD3.

- 3958 DD1

  This is the original server that was introduced in August 2008. This server is based on the IBM System x3850 M2 Type 7141. When it is used as a server in the TS7650G, its machine type and model are 3958 DD1.

- System console

  The system console is a TS3000 System Console (TSSC). This publication uses the terms *system console* and *TSSC* interchangeably.

The TS7650G gateway solution also connects to the following components:

- Disk controller

  The customer chooses the disk controller for use with the TS7650G. A list of compatible controllers is available at the following IBM Tape Systems Resource Library website:

  `http://www.ibm.com/systems/storage/tape/library.html`

  Verify compatibility in the TS7650/TS7650G ISV and the interoperability matrix document that you find on the website.

- Disk expansion unit

  The customer chooses the disk expansion unit for use with the TS7650G. A list of compatible expansion units is available at the following IBM Tape Systems Resource Library website:

  `http://www.ibm.com/systems/storage/tape/library.html`

  Verify compatibility in the TS7650/TS7650G ISV and the interoperability matrix document that you find on the website.

11.1.2 The TS7650 Appliance

Effective November 30, 2012 this server was withdrawn from the market. The terms that are presented here are for the IBM self-contained virtualization solution from the TS7650 family that includes a disk storage repository. The TS7650 Appliance consists of the following components:

- Server

  The 3958 AP1 server is based on an IBM System x3850 X5 Type 7143 model AC1 with ProtecTIER version 3.3. When it is used as a server in the TS7650 Appliance, its machine type and model are 3958 AP1. Use this machine type and model for service purposes.

- The system console

  The system console is a TS3000 System Console (TSSC). This publication uses the terms *system* console and *TSSC* interchangeably.

- Disk controller

  The disk controller for the TS7650 Appliance is an IBM Feature Code 3708: 4.8 TB Fibre Channel Disk Controller. Use this feature code for service purposes.

- Disk expansion unit

  The disk expansion unit for the TS7650 Appliance is an IBM Feature Code 3707: 7.2 TB Fibre Channel Disk Expansion Unit. Use this feature code for service purposes.

11.1.3 The TS7620 ProtecTIER Deduplication Appliance Express (3959 SM2)

The TS7620 appliance is based on machine type 3959. The model is SM2. Use this machine type and model for service purposes. The IBM ProtecTIER Entry Edition software is loaded on the IBM TS7620 ProtecTIER Deduplication Appliance to create a valid TS7620 ProtecTIER Deduplication Appliance solution. A separate order for ProtecTIER Entry Edition is required. Clients can choose between VTL configuration, OpenStorage (OST), or the newly available File System Interface (FSI), which supports Common Internet File System (CIFS) as a backup target. The TS7620 appliance consists of the following components:

- Server

  The TS7620 appliance uses the 3959 SM2 server. It is available in four configuration options with usable repository sizes of approximately 6 TB, 12 TB, 23 TB, and 35 TB. Upgrading from 6 TB to 12 TB requires only a license and software upgrade. For the higher capacity configuration, expansion racks also must be installed. The TS7620 hardware consists of the left and right slide rails, support tray, cable management assembly, external USB DVD drive, 3959 SM2 server, and expansion controllers.

- Customer replaceable unit (CRU) and field replaceable unit (FRU)

  Components that can be safely and easily self-serviced by the client are CRUs. Component removal and replacement that requires a higher degree of technical expertise and system knowledge are FRUs, and are to be serviced by IBM personnel, only.

- Internal and External

  Internal components are inside the server chassis, and are accessible only if the server's top cover is removed. External components are accessible with the server's cover in place

- Hot-swappable and cold-swappable

  Hot-swappable components do not require stopping input/output (I/O) activity or disconnecting the server from AC power before removing or replacing the component. Cold-swappable components cannot be removed or replaced while the system is running.

I/O must be stopped and the server must be disconnected from the AC power source before removal or replacement is started.

- FRU ID

  Each component has a unique FRU ID (part number). If you must order a replacement CRU or schedule a service call for an FRU, you must provide the FRU ID to the IBM customer support representative.

The following definitions are for general ProtecTIER terminologies:

- Replication

  A process that transfers logical objects such as virtual cartridges from one ProtecTIER repository to another. The replication function allows ProtecTIER deployment to be distributed across sites. Each site has a single or clustered ProtecTIER environment. Each ProtecTIER environment has at least one ProtecTIER server. The ProtecTIER server that is a part of the replication grid has two dedicated replication ports, Eth3 and Eth4 are used for replication. Replication ports are connected to the customer's wide area network (WAN) and are configured on two subnets as default.

- Replication grid

  A set of repositories that share a common ID and can potentially transmit and receive logical objects through replication. A replication grid defines a set of ProtecTIER repositories and actions between them and is configured by using the ProtecTIER Replication Manager, which is a software component that is installed on a ProtecTIER server or a dedicated host. The ProtecTIER Replication Manager should recognize all the members of the entire network the ProtecTIER Replication Manager handles on both replication subnets. The ProtecTIER Replication Manager is deployed separately from the ProtecTIER Manager on the client's ProtecTIER server. The ProtecTIER Replication Manager manages the configuration of multiple replication grids in an organization. An agent on every node in each ProtecTIER server interacts with the server and maintains a table of its grid members.

- Replication grid ID

  A number from 0 - 63 that identifies a replication grid within an organization.

- Replication grid number

  A repository that is a member in a replication grid.

- ProtecTIER Replication Manager

  A software component that is installed on a ProtecTIER server or a dedicated host. The ProtecTIER Replication Manager recognizes all the members of the entire network the ProtecTIER Replication Manager handles on both replication subnets. The ProtecTIER Replication Manager manages the configuration of multiple replication grids in an organization. An agent on every node in each ProtecTIER server interacts with the server and maintains a table of its grid members.

- Hub

  A replication and backup target. It receives replicated data from up to 12 spokes in a many-to-one replication system setup environment. In a many-to-many replication system setup environment, up to four hubs repositories can replicate to each other. In this case, the repositories are hub and spoke at the same time. In an OST mesh grid, the hub can be configured to replicate to another system and act as a source concurrently.

- Spoke

  A backup source that can replicate only to a single hub in a many-to-one replication system setup environment. Spokes are not supported in a many-to-many replication group.

- Replication pairs

  Two repositories within a replication grid that replicate from one to another.

- Replication policy

  A policy made up of rules that define a set of objects (for example, VTL cartridges) from a source repository to be replicated to a target repository.

- Repository unique ID (RID)

  A number that uniquely identifies the repository. The RID is created from the replication grid ID and the repository internal ID in the grid.

- Replication time frame

  A scheduled period of time for replication to take place for all policies.

- Shelf

  A container of VTL cartridges within a ProtecTIER repository. The ProtecTIER replication feature introduces the concept of a virtual shelf. As a general rule, replication always occurs from the source shelf to a destination shelf. As with physical tape shelves, there is a limit to the number of tapes that can be put on a virtual shelf. The limit is the result of subtracting the total number of tapes in all libraries from the total number of tapes supported in a single repository.

- Visibility switching control

  An automated process of the ProtecTIER replication feature that transfers the visibility of a cartridge from its master to its replica and vice versa. Just like a real physical tape, a virtual cartridge can be in or be visible only to the backup application in one location at a time. This is carried out by the ProtecTIER replication by using the VTL Import/Export slots.

11.2 Data deduplication

Data deduplication solutions from IBM use an advanced form of data compression that identifies and eliminates redundant data across the data landscape, which makes it possible to significantly reduce the amount of data that must be protected. This, in turn, dramatically increases the effective capacity of existing disk storage so that far less physical disk is required to protect the data, beyond the direct resource savings associated with needing less disk space, which can be in the hundreds of thousands or millions of dollars (see Figure 11-1). Data deduplication includes the following benefits:

- Greater productivity that comes from the ability to perform more frequent backups with the same amount of physical disk.
- Increased efficiency because of the greater likelihood that data can be restored from disk rather than a slower medium.
- Reduced energy consumption that results from reducing the amount of disk in operation.

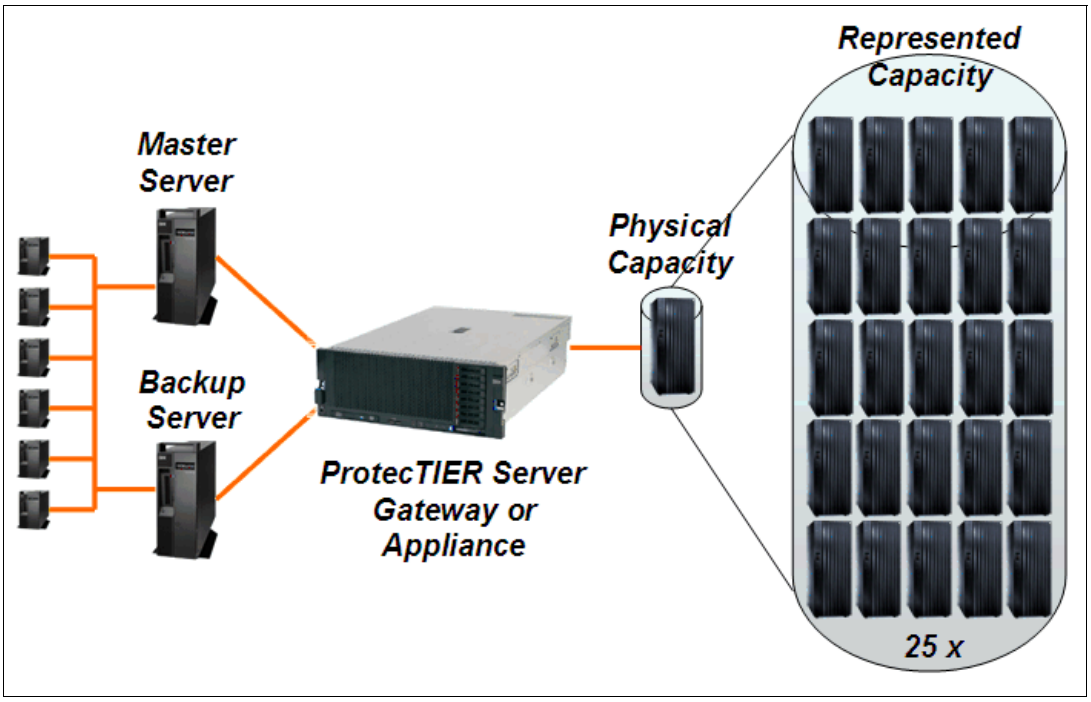


Figure 11-1 Disk savings with ProtecTIER

Data deduplication uses algorithms to compare data and eliminate duplicated or redundant data. Standard compression only works at the file level, while IBM Real-time compression appliances and database real-time compression work at the subfile level. Data deduplication can be applied at the subfile level to reduce data size across a much broader landscape.

HyperFactor technology uses a pattern algorithm that can reduce the amount of space that is required for storage in the backup environment by up to a factor of 25, based on evidence from existing implementations. The capacity expansion that results from data deduplication is often expressed as a ratio, essentially the ratio of nominal data to the physical storage used. A 10:1 ratio, for example, means that 10 times more nominal data is managed than the physical space that is required to store it. Capacity savings of 18:1 and greater were reported from data deduplication up to 25:1 in the case of IBM solutions.

11.2.1 Virtual tape library concept

A VTL is a software application that emulates physical tape while storing your data on a disk subsystem. Some vendors only sell the software, and you are required to assemble your own system by procuring the supported components (server, disk subsystem, and switches) and then you must integrate those components (à la carte). Other vendors might provide an appliance that includes and integrates all components. Still other vendors might provide a solution somewhere between the à la carte and the appliance solution.

Regardless of the procurement and integration method, all VTLs provide the basic function of emulating physical tape. To perform this function, the VTL software must accept the normal tape commands that are issued by a backup application and provide the appropriate responses back to the backup application. The VTL software also must store your data on the random access disk subsystem that allows it to retrieve the data and present it to the backup application as a sequential stream. The basic concept of VTL data storage is shown in Figure 11-2.

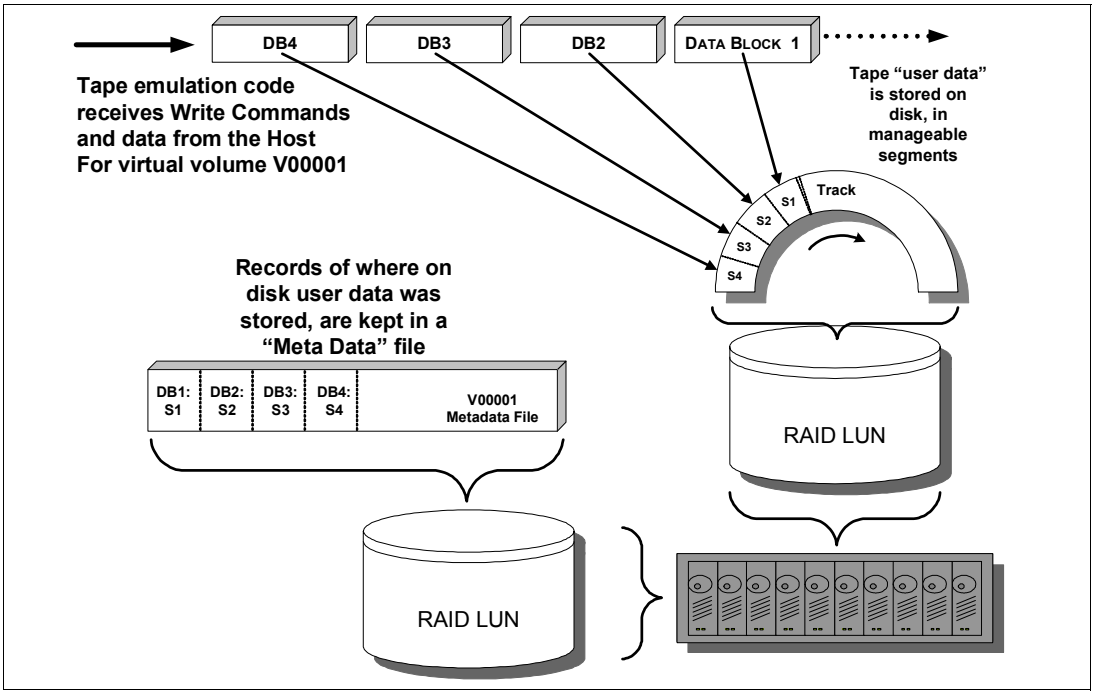


Figure 11-2 Virtual tape library concept

When data is written from the backup application to the VTL, the VTL receives the write commands and the data (in this case, virtual volume V00001). The data is stored on the disk in segments and the VTL uses a metadata file, or database, to keep track of each segment of data. When the VTL receives a read command from the backup application, it uses the metadata file to retrieve the data and present it to the backup application as sequential data.

One concept of a VTL that frequently causes confusion is the allocation of space for virtual cartridges after the backup application has expired a cartridge or marked it as scratch. When tape cartridges in a backup application are expired, a VTL emulates the operation of a physical tape library. This means that when the backup application expires a tape cartridge, it is simply an indication within the backup application that the tape cartridge is now available for scratch use. The backup application does not issue any commands to the tape library to modify the expired tape cartridge. In a physical library, the physical tape cartridge remains in the library and the data written on the tape cartridge stays on the tape cartridge until the backup application mounts the cartridge and performs a scratch write; which is a write from beginning of tape (BOT).

A VTL functions in the same way. When the backup application expires a virtual tape cartridge, the virtual tape cartridge stays in the library and the data that is contained on the virtual tape cartridge remains until the backup application performs a scratch write (write from BOT). When viewing the space use for the virtual library, the expired virtual tape cartridges continue to use allocated space until the scratch write is performed. If the used space on your VTL is high but you have sufficient virtual tape cartridges in expired or scratch status in the backup application, you might still be able to work within your installed capacity. If the used space on your VTL is high and you do not have sufficient virtual tape cartridges in expired status in your backup application, you might need to investigate increasing your capacity.

11.2.2 File System Interface concept

FSI is a new feature implemented in ProtectIER server version 3.2. The ProtecTIER FSI emulates Windows file system behavior and presents a virtualized hierarchy of file systems, directories, and files to Windows CIFS clients. Clients can perform all Windows file system operations on the emulated file system content. From ProtecTIER version V3.3, the server also supports NFS exports for UNIX hosts on the machine with CIFS shares. The ProtecTIER FSI interface is intended to be used for backup and restore of data sets by using a backup application. It is single-node only; FSI CIFS/NFS cannot be deployed on dual-node clusters.

Support for primary storage: Usage of the ProtecTIER FSI interface for primary storage is not supported as of this writing.

ProtecTIER can work in Active Directory mode or in Workgroup mode for CIFS shares. In the Active Directory mode, the ProtecTIER system joins the domain that is defined by the user. The domain users can work with the file systems, assuming that they are authenticated by the active directory server. In Workgroup mode, the ProtecTIER system manages the users that can access the file systems. You must define the users through the ProtecTIER Manager.

Important: The use of the ProtecTIER FSI as an NAS or Scale Out Network Attached Storage is not supported.

FSI is available for new installations only on the following platforms: DD5, AP1 (FCC 3170, DD4 based), and SM2. It is not supported on other platforms.

FSI has the following scalability specifications:

- Maximum file systems per repository: 128

  4 on SM2
- Maximum nominal file system size: 256TB
- Maximum files per file system: 1 million

- Maximum files per repository: 16 million

  4 million on SM2
- Maximum “open files” per repository (streams): 256
  - 128 on AP1
  - 64 on SM2

11.2.3 HyperFactor

ProtecTIER performs the basic VTL function but has the added benefit of data deduplication that is provided by the IBM HyperFactor technology. HyperFactor was designed from the top down to overcome the known limitations of hash-based deduplication.

Hash-based data deduplication is an all or nothing proposition. A chunk of data is identical or it is not. Changing a single byte renders a chunk completely different, even though almost all of the data remains the same. Thus, systems that look for exact chunk matches have many missed opportunities for data factoring because the new data often is closely related to previously stored data.

HyperFactor takes a different approach and therefore reduces the phenomenon of missed factoring opportunities. Rather than depending on exact chunk matches, HyperFactor finds matches between similar data. When new data is received by ProtecTIER, HyperFactor finds any similar data elements that were stored. This search is extremely quick and uses a small and efficient memory-resident index. After the similar data elements are found, HyperFactor then compares the new data to the similar data to identify and store only the byte-level changes.

With this approach, HyperFactor can surpass the reduction ratios attainable by any other data reduction method. HyperFactor can reduce any duplicate data, regardless of its location or how recently it was stored. Unlike hash-based techniques, HyperFactor finds duplicate data without needing exact matches of chunks of data. When new data is received, HyperFactor checks to see whether similar data was stored. If similar data was stored, only the difference between the new data and previously stored data must be retained. Not only is this an effective technique of finding duplicate data, but it performs well.

High performance is enabled by using a limited amount of memory and computation processing to store the index, which requires fewer items and much less memory than with hash-based data deduplication. HyperFactor requires only 4 GB of memory to index 1 PB of data, which leads to a fast and efficient system that can search its index without disk I/O or large amounts of RAM.

The core technology in ProtecTIER-HyperFactor is a series of algorithms that factor, or deduplicate, data efficiently. In each new backup, HyperFactor finds the data in common with previous backups. This common data in the new backup is effectively filtered out and pointers are used to reference existing data in the repository. The net effect is that the entire content of the new backup is stored in the space that is required to store only the small fraction of it that is truly new data.

Over time, the effect of HyperFactor is a system-wide *factoring ratio*. In essence, the factoring ratio is the ratio of nominal data (the sum of all user data backup streams) to the physical storage that is used. With ProtecTIER, this factoring ratio can grow to 25:1 or more, meaning that 25 times more nominal data is managed by ProtecTIER than the physical space required to store it.

The factoring ratio of your data depends heavily on the following key variables:

- Data retention period: The period (usually measured in days) that defines how long clients keep their disk-based backups online. This period typically ranges from 30 - 90 days, but can be more or less.
- Data change rate: The rate that the data that is received from the backup application changes from backup to backup. This measurement has most relevance when similar backup policies are compared (data change rates might range from 1% - 25% or more, but are difficult to directly observe).

ProtecTIER performs the deduplication process on data ingest, which means data deduplication is performed inline.

For more information about deduplication, VTL, and FSI, see *IBM System Storage TS7600 with ProtecTIER v3.2 User's Guide*, GA32-0922.

11.3 TS7650G ProtecTIER Deduplication Gateway

The IBM TS7650G is a preconfigured virtualization solution of IBM systems, and the IBM revolutionary ProtecTIER data deduplication software that is designed to improve backup and recovery operations. The solution is available in a single node or two node cluster configurations that are designed to meet the disk-based data protection needs of various IT environments enterprise data centers organizations.

The IBM TS7650G, comprising 3958 DD5 hardware combined with IBM ProtecTIER Enterprise Edition V3.3 software, offers the data deduplication technology. The TS7650G does not have disk installed but uses a customer-supplied disk subsystem for back-end disk.

Important: ProtecTIER software is ordered with the TS7650G order, but it is shipped separately.

11.3.1 TS7650G Gateway Models

There are a few models of the IBM virtualization solution from the TS7600 family that do not include a disk storage repository, which allows the client to choose from various storage options. The TS7650G consists of the 3958 DD5, 3958 DD4, 3958 DD3, or 3958 DD1 models, which are four types of servers that are used as the ProtecTIER Gateway. The 3958 DD1, 3958 DD3, and 3958 DD4 are the oldest models.

The 3958 DD5 is the latest, fourth-generation server available from May 2012 and shipped with the ProtecTIER server software version 3.2 or higher. This server is based on the x7143 type. When it is ordered as the ProtecTIER TS7650G, the machine type and model are 3958 DD5. Use this machine type and model for service purposes.

11.3.2 TS7650G ProtecTIER Deduplication Gateway (3958 DD5)

The TS7650G, comprising the 3958 DD5 hardware combined with IBM ProtecTIER Enterprise Edition software, addresses the data protection needs of enterprise data centers. The solution offers high performance, high capacity, scalability, and a choice of disk-based targets for backup and archive data. The TS7650G offers the following features:

- Inline data deduplication powered by HyperFactor™ technology.
- Multi-core virtualization and deduplication engine.
- Clustering support for higher performance and high availability.
- Fibre Channel ports for host and server connectivity.
- Virtual tape emulation of up to 16 VTLs per single node or two-node cluster configuration and up to 512 virtual tape drives per two-node cluster or 256 virtual tape drives per single node.
- Symantec OpenStorage support.
- File System Interface Common Internet File System (FSI-CIFS) support for Microsoft Windows based network-attached storage (NAS) backup environments.
- Emulation of the TS3500 tape library with IBM LTO Ultrium 3 tape drives.
- Emulation of the Quantum p3000 tape library with DLT7000 tape drives or IBM LTO Ultrium 2 tape drives.
- Emulation of the DTC IBM VTF® 0100 VTLs with DLT7000 tape drives or IBM LTO Ultrium 2 tape drives.
- Scales up to 1 PB of physical storage over 25 PB of user data (depending on your deduplication ratio).
- VTL or OST configuration. For more information, see “Virtual tape library concept” on page 364 or “ProtecTIER OpenStorage” on page 385. Both modes cannot be run on the same 3958 DD5 system.
- The system console is a TS3000 System Console (TSSC).

The TS7650G is an enterprise-class data protection platform that quickly and safely protects business information while reducing the amount of space that is required to store it.

Deploying the TS7650G can help organizations more efficiently protect their corporate data on disk-based storage while helping them manage the exponential growth of new data through reduction and elimination of duplicate data in their backups.

The use of disk cache as a deduplicated storage pool with existing backup applications offers a potentially lower total cost of ownership than conventional disk. To facilitate backup applications that are designed for use with tape storage, the TS7650G emulates a traditional tape library unit, so deployment does not force any changes to your existing data protection processes.

Figure 11-3 shows the components of the TS7650G ProtecTIER Deduplication Gateway DD5.

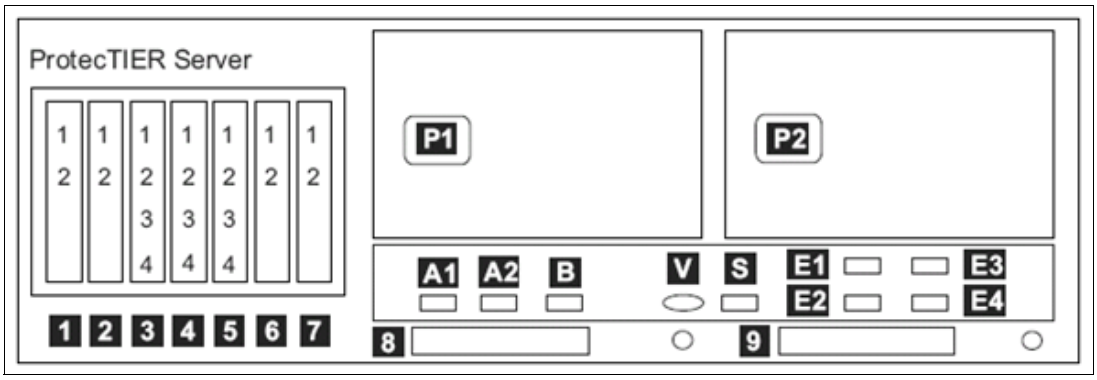


Figure 11-3 TS7650G ProtecTIER Deduplication Gateway DD5 generic rear view

Table 11-1 lists the slot assignment, ports, and connections.

Table 11-1 3958 DD5 Server rear view: Slot assignments, ports and connections

Slot, Port or Connection	VTL use	OST or FSI use (Feature 3456)	OST or FSI use (Feature 3457)
Slot 1	Emulex HBA for front-end attachment	Blank	Blank
Slot 2	Emulex HBA for front-end attachment	Blank	Blank
Slot 3	Blank	Intel Pro Quad-port gigabit Ethernet adapter (Port 1 = Eth8, Port 2 = Eth9, Port 3 = Eth10, Port 4 = Eth11)	Dual-port 10 gigabit Ethernet adapter
Slot 4	Blank	Intel Pro Quad-port gigabit Ethernet adapter (Port 1 = Eth4, Port 2 = Eth5, Port 3 = Eth6, Port 4 = Eth7)	Dual-port 10 gigabit Ethernet adapter
Slot 5	Intel Pro Quad-port gigabit Ethernet adapter (Port 1 = Eth0, Port 2 = Eth1, Port 3 = Eth2, Port 4 = Eth3)	Intel Pro Quad-port gigabit Ethernet adapter (Port 1 = Eth0, Port 2 = Eth1, Port 3 = Eth2, Port 4 = Eth3)	Quad-port gigabit Ethernet adapter
Slot 6	QLogic HBA for back-end attached disks	QLogic HBA for back-end attached disks	QLogic HBA for back-end attached disks
Slot 7	QLogic HBA for back-end attached disks	QLogic HBA for back-end attached disks	QLogic HBA for back-end attached disks

Table 11-1 on page 369 lists the capabilities of the Gateway models.

Table 11-2 Capabilities of Gateway models

Component	3958 DD1	3958 DD3	3958 DD4	3958 DD5
IBM System	x3850 M2	x3850 M2	x3850 X5	x3850 X5
CPU	4x quad core (16 cores)	4x hex cores (24 cores)	4x octo cores (32 cores)	4x ten cores (40 cores)
RAM	32 GB	32 GB	64 GB	64 GB

Note: For customers who are using the 3958 DD3 models, there is a new option to increase the memory of the ProtecTIER system from 32 GB to 64 GB. This upgrade is only necessary if you want to have a repository size greater than 512 TB with replication enabled and using more than 128 virtual drives per node.

In a clustered configuration, the upgrade procedure should allow for one node to remain online, which provides client data access while the peer node in the cluster undergoes the upgrade procedure.

You can upgrade from an existing 3958 DD3 single node to a clustered gateway with a 3958 DD5.

The 3958 DD3 does not support OST service modes.

11.3.3 Disk array

A critical hardware component in a TS7650G implementation is the disk array that holds the ProtecTIER repository. The repository holds the ProtecTIER deduped data.

For more information about the types of supported disk arrays, see the section titled “independent software vendor (ISV) matrix” at this website:

http://www.ibm.com/systems/storage/tape/ts7650g/index.html

The disk array is not packaged as part of a TS7650G order from IBM. You can order a new disk subsystem from IBM or another vendor (if supported) or you can use an existing disk subsystem at your site that is listed in the ISV matrix.

ProtecTIER does not require more compression to be effective. It performs compression, by default, after the deduplication process. Disk arrays that perform their own compression should not be used for ProtecTIER VTLs.

For the best disk array attachment and configuration, contact your IBM technical representative to size your solution.

11.3.4 Deployment

A TS7650G and TS7650-AP1 can be deployed in a single node or a two-node cluster, depending on the purchased configuration feature (FSI is stand-alone only). The two-node cluster provides increased performance and provides hardware redundancy and a high-availability solution that can allow you to continue to have access to all virtual data stored even if one node fails, with some manual intervention.

Table 11-3 shows the different performance parameters for different TS7650 Gateway configurations.

Table 11-3 Performance expectations of TS7650G servers

	Single node backup	Single node restore	Dual node backup	Dual node restore
VTL	1600 MBps	2200 MBps	2500 MBps	3200 MBps
OST 10Gb	1300 MBps	1600 MBps	2200 MBps	2400 MBps
FSI	700 MBps	700 MBps	N/A	N/A

Single node configuration

A single node TS7650G (as shown in Figure 11-4) contains a single repository. Within that repository, you can define a VTL with the following configurations:

- Up to 16 virtual libraries
- Up to 256 virtual tape drives
- Up to 512,000 virtual cartridges

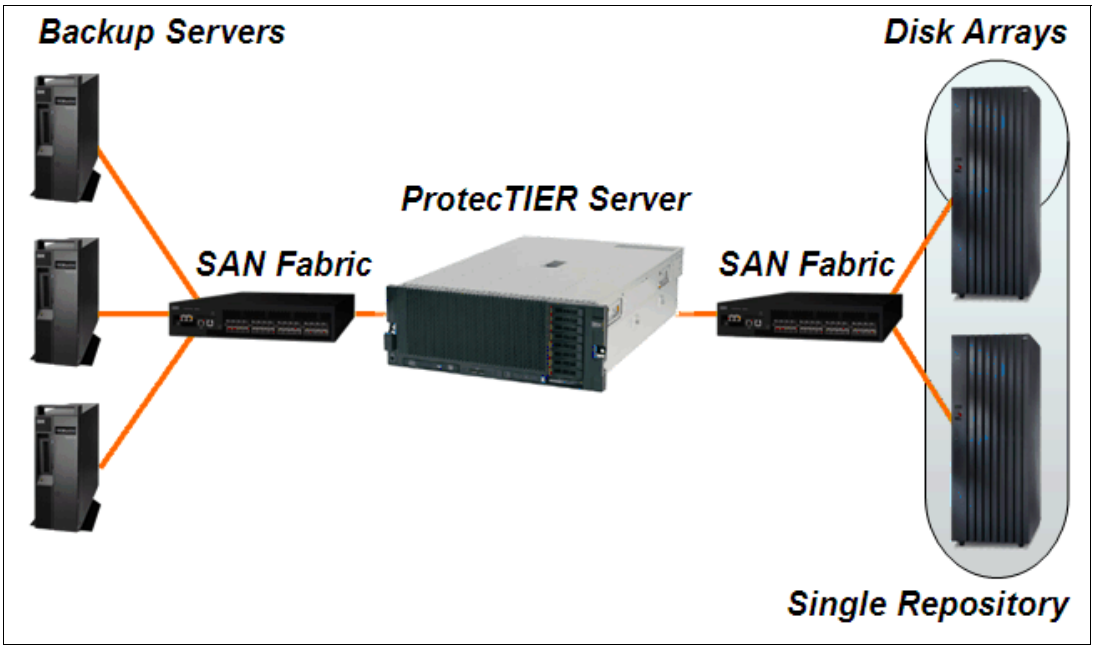


Figure 11-4 TS7650G single node VTL configuration

A single node configuration has four front-end ports for attaching backup applications. Figure 11-4 shows an example of single node configuration.

Two-node cluster configuration

A two-node cluster TS7650G configuration has two IBM System x3850 model 7143 and provides better performance (depending on the configuration of attached disks) than a single node system. A dual-node cluster configuration has a single repository with the same dimensions as a stand-alone configuration. Within that repository, you can define a VTL with the following configurations:

- Up to 16 virtual libraries
- Up to 512 virtual tape drives (256 per node)
- Up to 512,000 virtual cartridges

A two-node cluster configuration has another network power switch that is used to automatically control the power to a failed node. It also has two Ethernet switches that are used to connect the TS7650G servers with the network power switch, as shown in Figure 11-5. The Ethernet switches also connect the TS7650G servers with the ProtecTIER Manager workstation and the TS3000 System Console (TSSC).

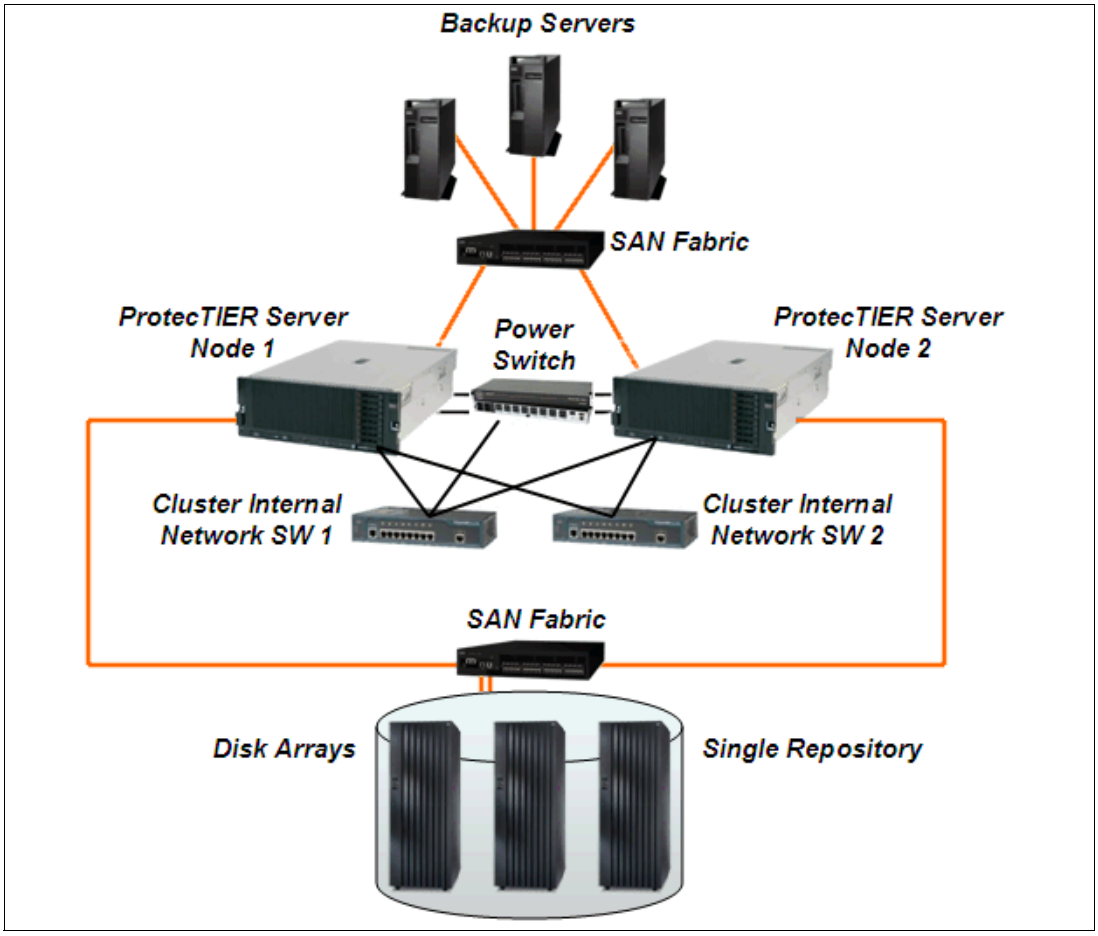


Figure 11-5 TS7650G two-node cluster VTL configuration

The two-node cluster configuration was designed for better performance, but having redundant nodes might provide improved availability for a single node outage. Because both nodes share a single repository, they have access to all virtual resources that are defined in the repository. As appropriate for your operations, you can have a single virtual library or multiple virtual libraries. Within a virtual library, for example, the robot is assigned to one node in the two-node cluster, but virtual tape drives that are contained in a library can be defined to either node to provide load balancing.

Control Path Failover enabled with a two-node cluster and a single VTL

When you enable Control Path Failover (CPF) you can assign multiple robots to one tape library, as shown in Figure 11-6 on page 373. By using TS3500 tape library emulation and IBM tape device driver on your host, you can enable CPF, which means there are redundant paths to the robot. In case of a failure on node 1, you still have a path to the robot on node 2 and paths to 3 drives, and you can access all cartridges.

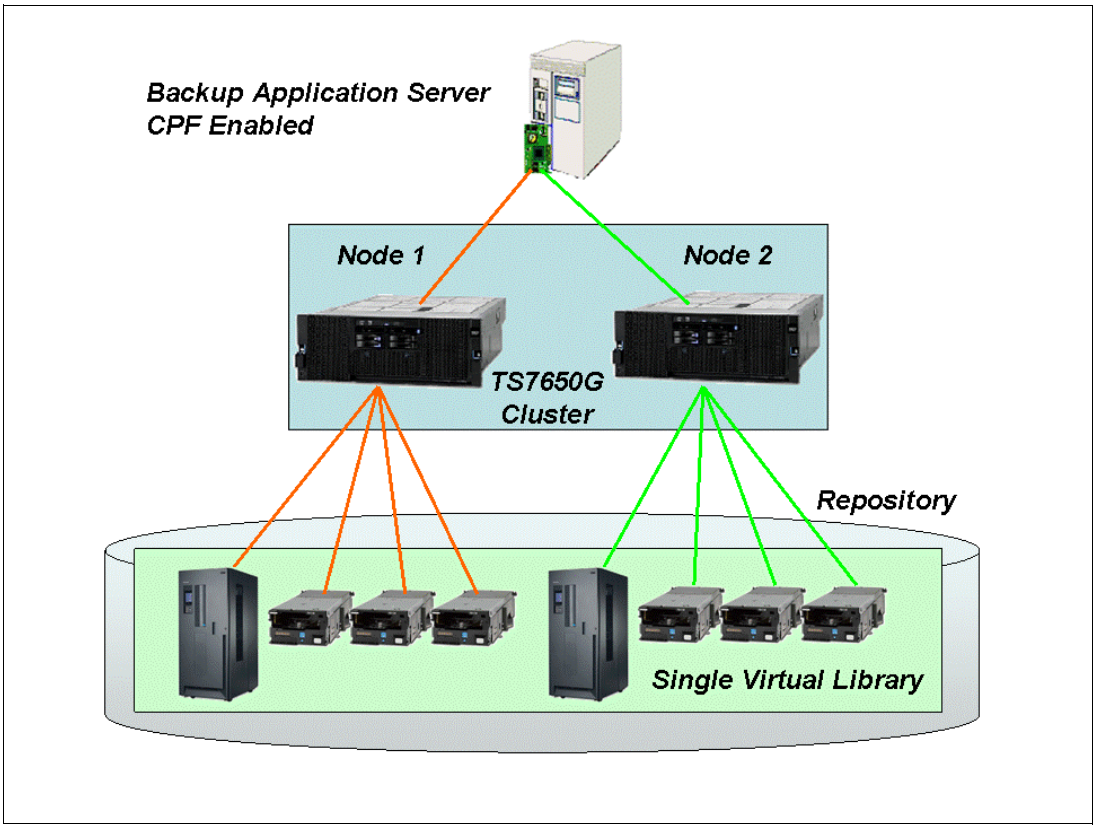


Figure 11-6 TS7650G two-node cluster configuration with one virtual tape library with CPF enabled

This configuration does not have a single point of failure because there is one virtual robot per TS7650G server. If node 1 fails, node 2 can continue to mount virtual tapes and run backup application jobs (or vice versa), and still access all the virtual cartridges in the VTL. There is no need to reassign the VTL robot or virtual tape drives to node 2. However, if there are more jobs running in the queue than the number of drives available, some of the jobs must wait until one of the drives becomes available.

Note: In addition to the CPF enabled by IBM tape device driver, Symantec NetBackup 6.5.2 onwards supports multiple paths for robots or tape libraries to achieve highly available tape libraries.

As you can see, with a two-node cluster configuration, you can continue to operate because of the redundancy of the nodes, but you do not have a failover or high availability for the backup server.

Two-node cluster with two virtual tape libraries

Figure 11-7 on page 374 shows a TS7650G two-node cluster configuration with two virtual tape libraries. For this example, we assume a single backup application on a single server with a requirement for six virtual tape drives. Each virtual library consists of a VTL robot and six virtual tape drives. The virtual robot and six virtual tape drives from virtual tape library A are assigned to node 1 and the virtual robot and six virtual tape drives from virtual tape library B are assigned to node 2. The backup application actively uses both VTLs, but only uses three of the virtual tape drives in each virtual library during normal operations.

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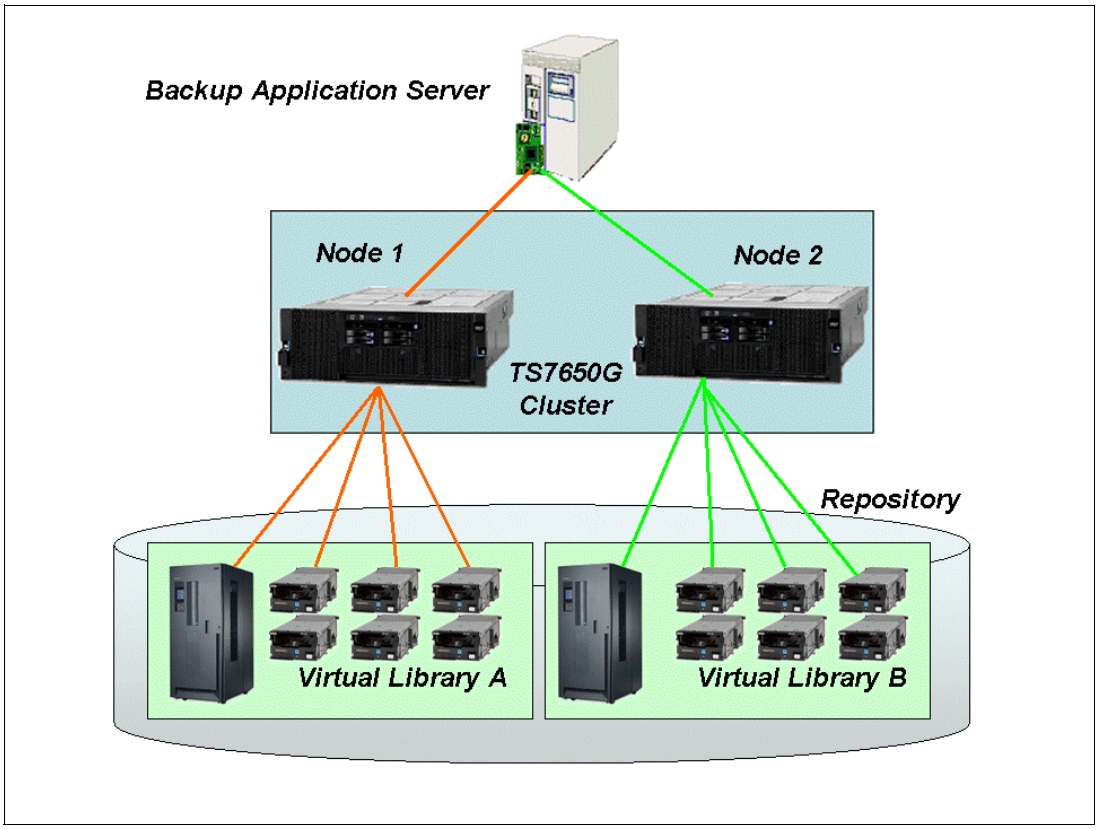


Figure 11-7 TS7650G two-node cluster configuration with two virtual tape libraries

This configuration does not have a single point of failure because there is one virtual robot per TS7650G server. If node 1 fails, node 2 can continue to mount virtual tapes and run backup application jobs (or vice versa). However, you do not have access to the virtual cartridges in virtual tape library A. All tasks running on node 1 fail.

By using the ProtecTIER Manager, you can reassign the VTL robot and virtual tape drives in virtual library A to node 2, perform the appropriate reconfiguration in your backup application, and restart the backup application tasks or server, as appropriate for your backup application. Alternatively, if you do not need to access the virtual cartridges in library A, the backup application can continue using node 2 and VTL B with six virtual tape drives by using the extra three drives that were defined but previously unused.

Two-node cluster with a single virtual tape library

Figure 11-8 on page 375 shows a TS7650G two-node cluster configuration with a single VTL. For this example, we assume a single backup application on a single node with a requirement for six virtual tape drives. The VTL consists of a virtual tape library robot and six virtual tape drives. To provide load balancing, the virtual robot and three virtual tape drives are assigned to node 1 and the other three virtual tape drives are assigned to node 2.

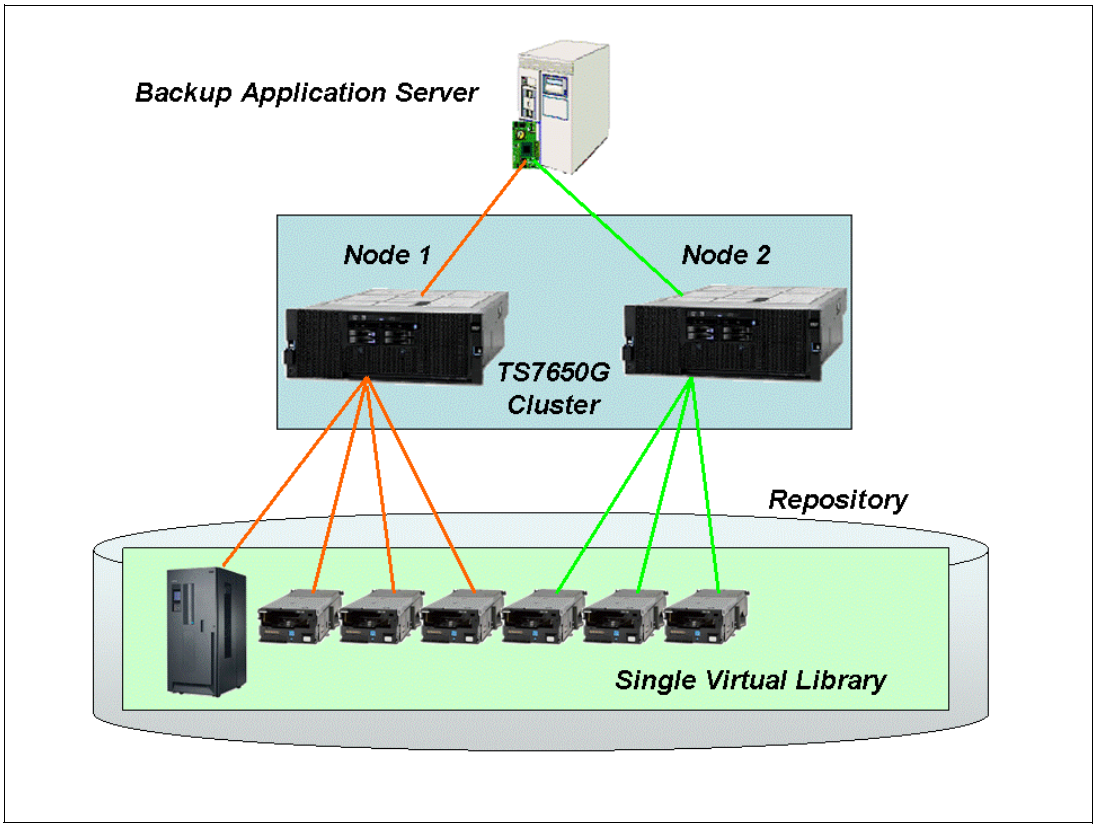


Figure 11-8 TS7650G two-node cluster with single virtual tape library

While this configuration can provide load balancing, it does have a single point of failure. If node 1 fails, the VTL robot is unavailable and all access to the VTL is lost and all jobs fail. B using the ProtecTIER Manager, you can reassign the VTL robot and virtual tape drives to node 2, perform the appropriate reconfiguration in your backup application, and restart the backup application tasks or server, as appropriate for your backup application.

If node 2 were to fail instead of node 1, you lose three virtual tape drives and the backup application tasks that were running on that node. However, you can continue to run on node 1 with the three virtual tape drives available. You can reassign the virtual tape drives to node 1. You must restart the tasks that were running on node 2.

11.4 TS7650 ProtecTIER Deduplication Appliance

This server type was withdrawn from market on November 30, 2012. The IBM TS7650 ProtecTIER Deduplication Appliance is a preconfigured virtualization solution of IBM storage, IBM systems, and the IBM revolutionary ProtecTIER data deduplication software that improves backup and recovery operations. This server is not just a bundle of components, but a truly integrated solution that makes it easy to harness the power of deduplication without making radical changes to the existing environment. The solution is available in four configurations that meet the disk-based data protection needs of various organizations, from mid-sized IT environments to enterprise data centers.

11.4.1 TS7650 Deduplication Appliance

The TS7650 Appliance includes a disk repository and consists of the following components:

- Server

  The 3958 AP1 system is based on an IBM System x3850 X5 Type 7143. When used as a server in the TS7650 Appliance, its machine type and model are 3958 AP1. Use this machine type and model for service purposes.

- System console

  The system console is a TS3000 System Console (TSSC). This publication uses the terms *system console* and *TSSC* interchangeably.

- Disk controller

  The disk controller is an IBM DS5020. When it is used as a disk controller in the TS7650 Appliance, its machine type and model are 1814 70H. Use this machine type and model for service purposes.

- Disk expansion module

  The disk expansion module is an IBM DS4000® EXP810 Storage Expansion Unit. When it is used as a disk expansion module in the TS7650 Appliance, its machine type and the IBM disk expansion module are an IBM DS4000 EXP810 Storage Expansion Unit. Each expansion unit supports 16 450 GB (15k rpm), 4 Gbps, Fibre Channel disk drive modules.

Important: All components are mounted in and shipped in an IBM 36U Rack unit.

11.4.2 TS7650 ProtecTIER Deduplication Appliance features

The IBM TS7650 Appliance offers the following features that can create savings in physical storage, processing, and network bandwidth:

- IBM ProtecTIER with patented HyperFactor.
- Data deduplication technology.
- ProtecTIER native replication technology.
- IBM System x server for enterprise-level performance.
- IBM Storage Controller with highly reliable Fibre Channel drives.
- Rack, cables, and other components that are needed to provide a complete solution.
- Up to 25 times or more storage capacity reduction.
- Emulation of up to 12 virtual libraries, 256 virtual drives, and 128,000 virtual cartridges.
- Preconfigured with a DS5020 for storage repositories.
- Simplified configuration and deployment.
- VTL, OST, or FSI configuration. These modes cannot be run on the same system.

11.4.3 Available models

IBM TS7650 Appliance was available in the four configurations that are shown in Table 11-4.

Table 11-4 Available models

Size of repository	7 TB configuration	18 TB configuration	36 TB configuration	36 TB two node configuration
Nominal capacity[a]	175 TB	450 TB	900 TB	900 TB
Maximum throughput	Up to 100 MBps	Up to 250 MBps	Up to 500 MBps	Up to 500 MBps

a. Based on deduplication ratio of 25:1

11.4.4 Deployment

A TS7650 Appliance can be deployed in a single node or two-node cluster. The two-node cluster provides an increased number of virtual drives and provides hardware redundancy that can allow you to continue to have access to the virtual data after a node failure with some manual intervention.

Single node configuration

A single node TS7650 Appliance (as shown in Figure 11-9) contains a single repository. Within that repository, you can define a VTL with the following configurations:

- Up to 12 virtual libraries per two-node cluster
- Up to 256 virtual tape drives
- Up to 128,000 virtual cartridges

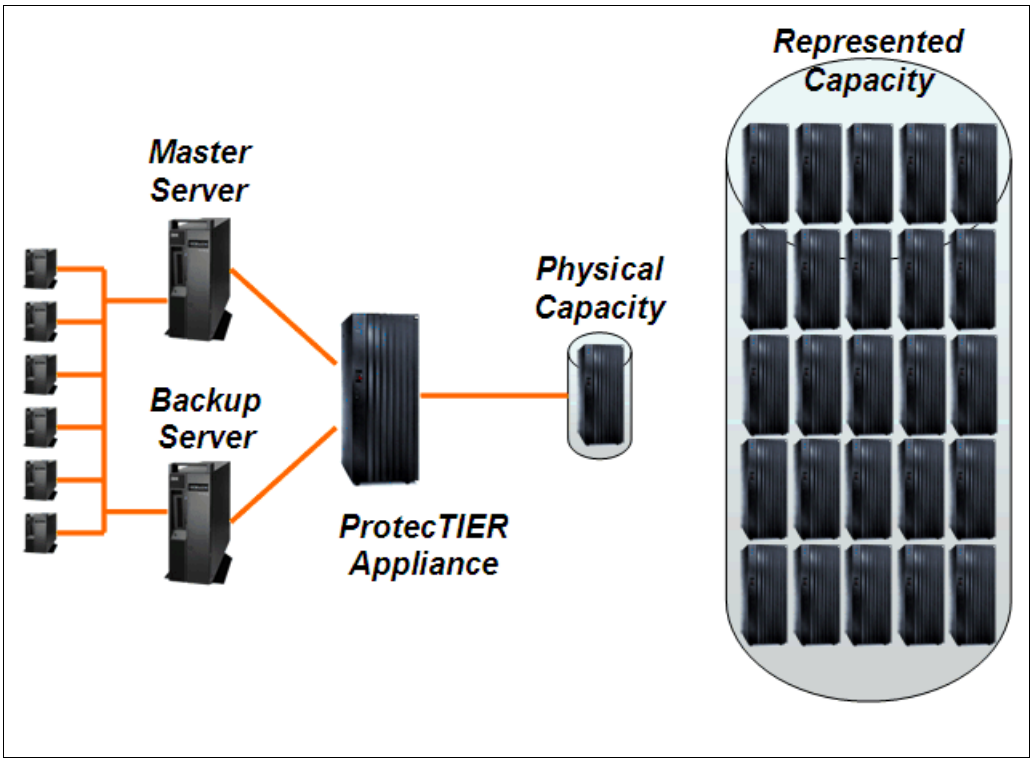


Figure 11-9 Single node appliance VTL configuration

Two-node cluster configuration

A two-node cluster TS7650 Appliance configuration (as shown in Figure 11-10 on page 378) has two IBM System x3850 X5 Type 7143. A two-node cluster configuration has the same repository dimensions as a single node configuration. A two-node cluster TS7650 Appliance contains a single repository. Within that repository, you can define a VTL with the following configurations:

- Up to 12 virtual libraries
- Up to 512 virtual tape drives (256 per node)
- Up to 128,000 virtual cartridges per node

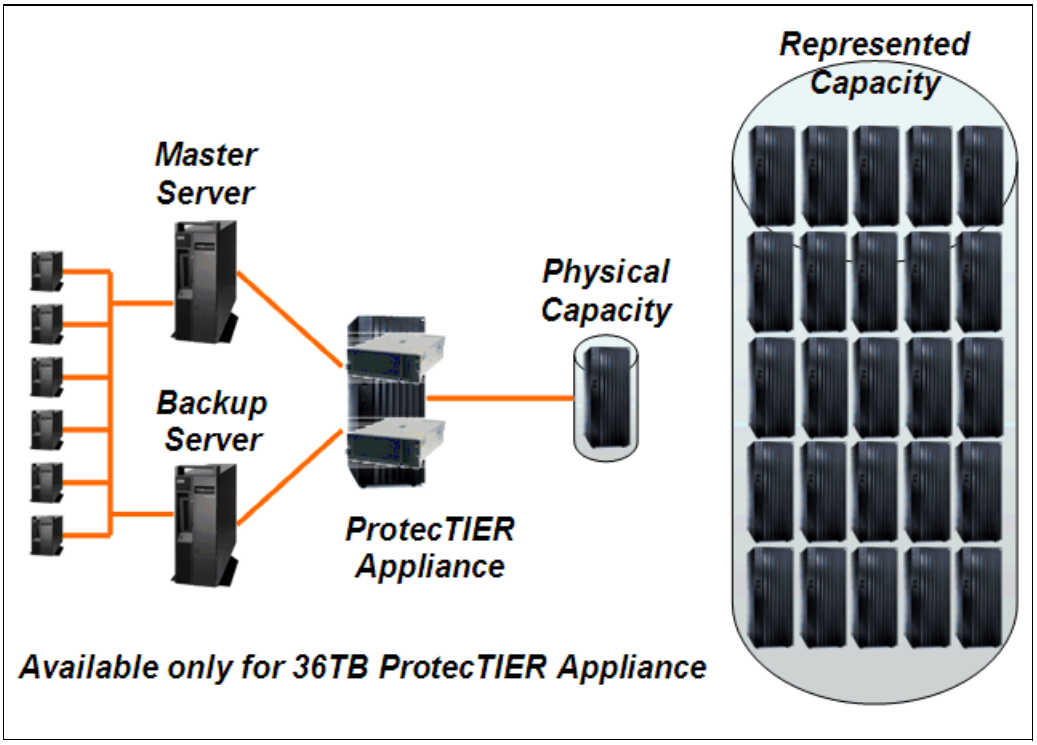


Figure 11-10 Two-node cluster appliance VTL configuration

A two-node cluster TS7650 Appliance and Gateway configuration (as shown in Figure 11-11) has another network power switch that is used to automatically control the power to a failed node. It also has two Ethernet switches, which are used to connect the TS7650 servers with the network power switch. The Ethernet switches also connect the TS7650 servers with the ProtecTIER Manager workstation and the TS3000 System Console (TSSC).

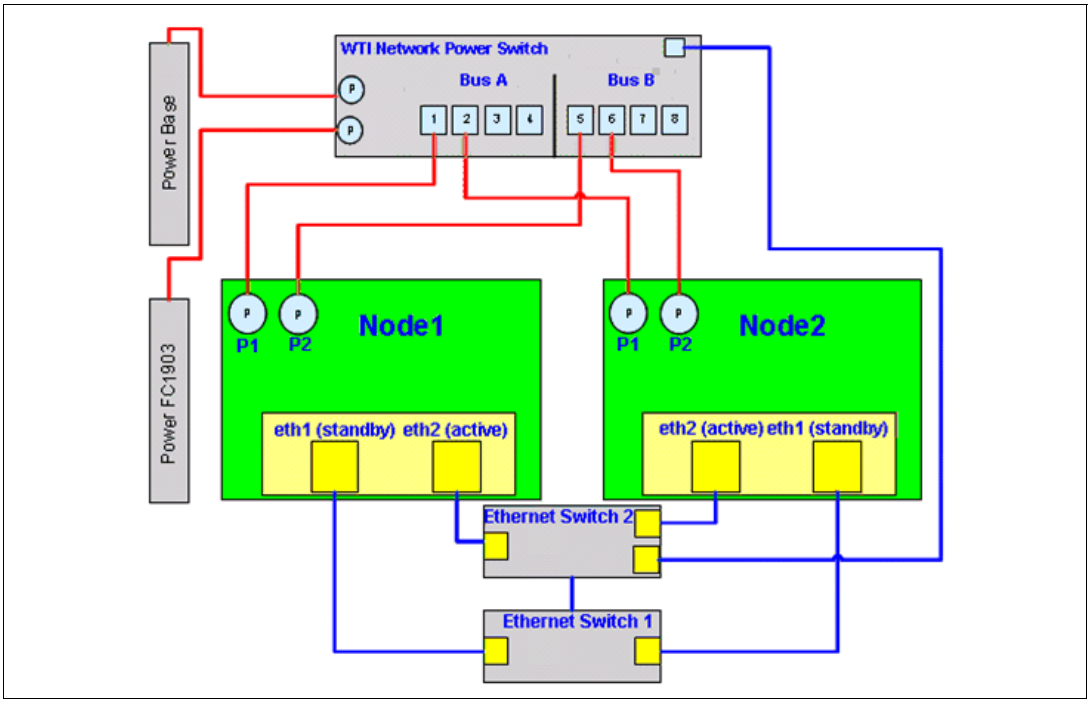


Figure 11-11 Power switch control

Because both nodes share a single repository, they have access to all virtual resources that are defined in the repository. As appropriate for your operations, you can have a single VTL or multiple VTLs. In a VTL, for example, the robot is assigned to one node in the two node cluster, but virtual tape drives that are contained in a library can be defined to either node to provide load balancing.

11.5 TS7620 ProtecTIER Deduplication SMB Appliance

The IBM TS7620 ProtecTIER Deduplication Appliance (TS7620 Appliance) is a client-installable data deduplication and replication solution that compresses and stores backup data within the TS7620. It can be configured to run either as a VTL, OST system, or an FSI server that providing CIFS shares and NFS exports.

Important: The TS7620 Appliance is available in a stand-alone one-node configuration only.

Do not connect a 3959 SM2 server directly to a public optical network. The client must use another connectivity device between a 3959 SM2 optical Host Bus Adapter and an external public network. Use a device such as a patch panel, router, or switch. You do not need another connectivity device for optical fiber connectivity that does not pass through a public network.

The TS7620 Appliance uses IBM technology and software to emulate a TS3500 tape library unit that contains IBM Ultrium LTO-3 tape drives. By using this emulation, you can achieve the following operational and throughput efficiencies:

- Backup window reduction
- Restoration time reduction
- Direct access to the information
- Data sharing and resource virtualization optimization
- Operational efficiency
- Improved sharing of VTLs across applications and servers

11.5.1 TS7620 hardware components

The TS7620 Appliance consists of the following components:

- Left and right slide rails
- Support tray
- Cable management assembly
- An external USB DVD drive
- 3959 SM2 server (as shown in Figure 11-12 on page 380 and Figure 11-13 on page 381)
- Expansion racks (as shown in Figure 11-14 on page 381)

The shelf rail kit occupies another 1-U rack space (3U in total frame space).

The TS7620 Appliance includes the following capacity models:

- Small 7620 Appliance repository binary capacity of 6 TB. For more information about storage size, see Appendix D, “Data storage values” on page 473.

  This configuration is ideal for clients with 500 GB or fewer incremental backups per day and average data growth.

- Medium TS7620 Appliance repository binary capacity of 12 TB.

  This configuration is ideal for clients with 1 TB or less incremental backups per day and 1 TB to 3 TB full backups each week with average to rapid data growth.

  The capacity of this configuration can be increased further with expansion racks, which extends the capacity of the server to 23 TB or 35 TB. ProtecTIER software V3.3 is needed to support this configuration.

A TS7620 small model of 6 TB capacity can be upgraded to a 12 TB model by a software upgrade and no other hardware is required.

The 3959 SM2 Appliance server includes the following components:

- One six core 2.4 GHz Intel XEON processor
- Twelve 2 TB nearline-SAS hard disk drives (HDDs) for repository
- Two 500 GB SAS for boot
- Two power supplies
- RAID battery backup unit
- Six 8 GB Dual in-line memory modules (DIMMs)
- Dual-port 8 Gb Emulex Fibre Channel host bus adapter for VTL
- Dual-port 1 Gb Ethernet adapter for OST
- Dual-port 1 Gb Ethernet adapter for FSI/CIFS

The performance characteristics of the SM2 are listed in Table 11-5.

Table 11-5 TS7620 SM2 performance

	VTL	OST	FSI
Single stream backup, restore	80 MBps	60 MBps	40 MBps
Multi-stream backup, restore, replication	120 MBps	120 MBps	120 MBps

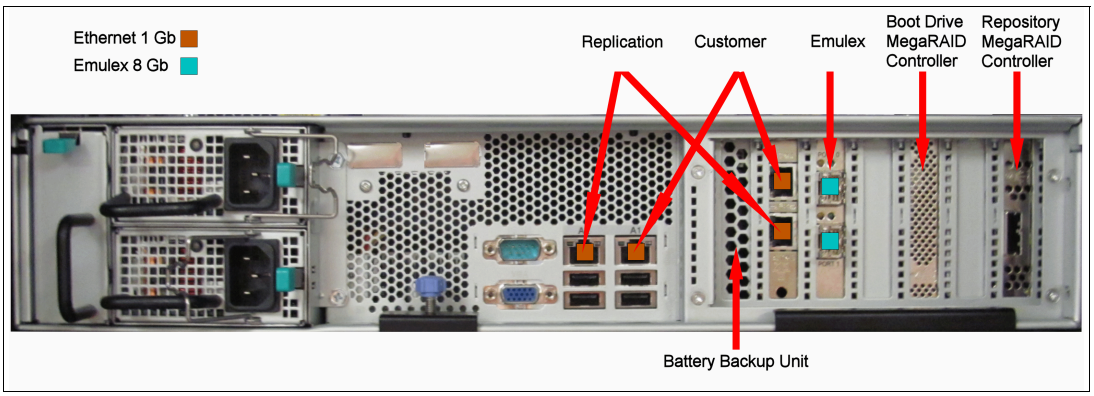


Figure 11-12 Back view of 3959 SM2 server for VTL

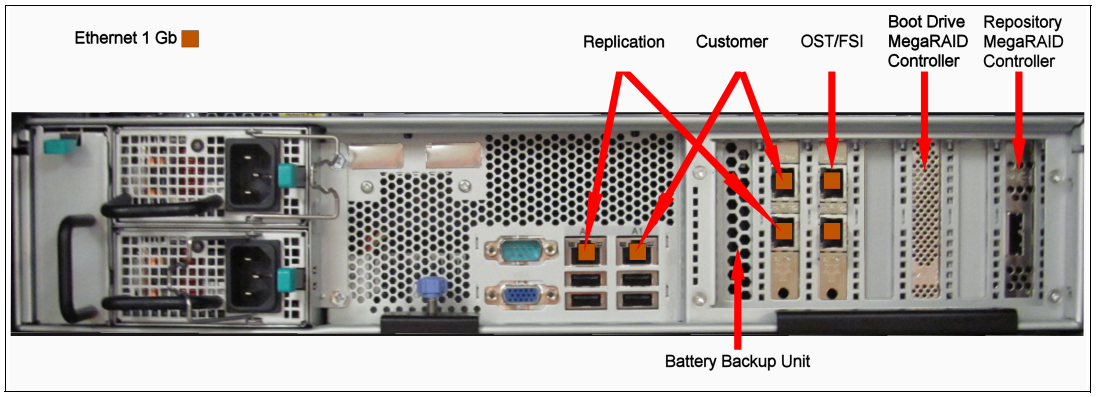


Figure 11-13 Back view of 3959 SM2 server for Open Storage or FSI

Also, you can see all hardware components by using ProtecTIER Manager GUI, as shown in Figure 11-15 on page 382, and choosing the resources at the hardware resources column.

Important: When expansion racks are added to the SM2 OST/FSI, another 4-port Ethernet adapter must be added to slot 4 on the SM2 base server.

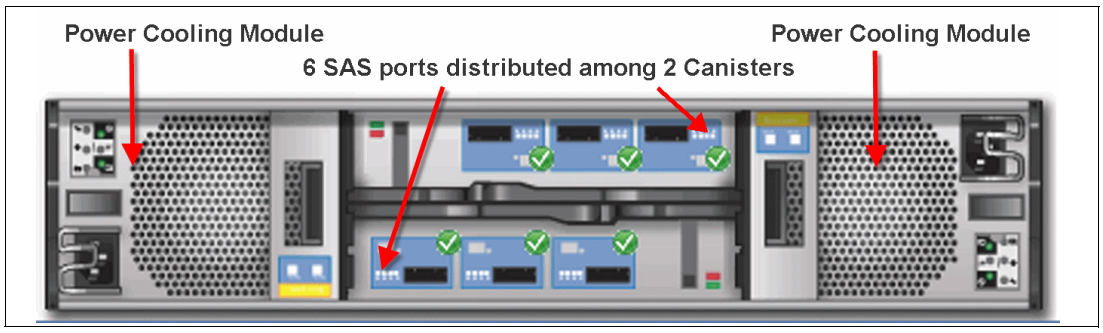


Figure 11-14 Back view of the SM2 expansion controller with 6 SAS ports

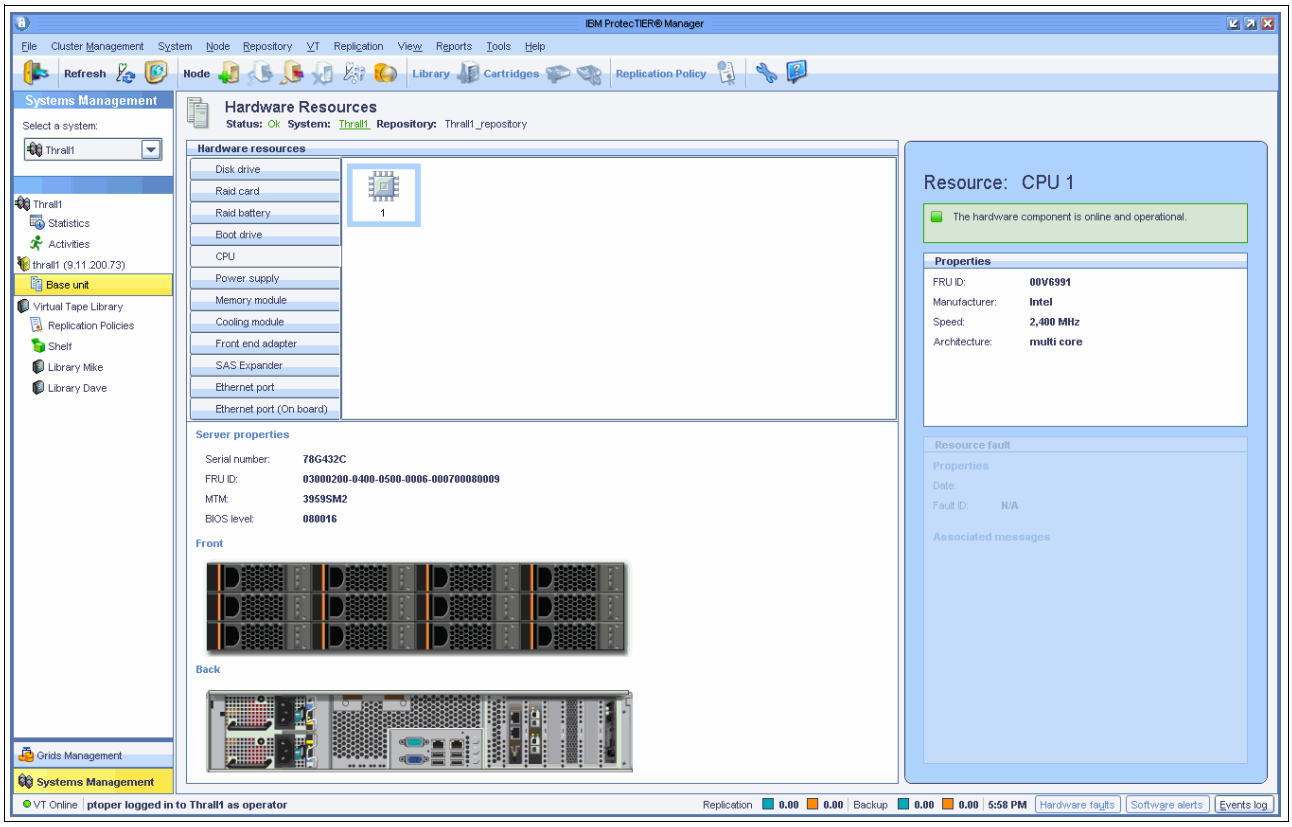


Figure 11-15 ProtecTIER Manager hardware resource view 3959 SM2

11.5.2 Deployment

The TS7620 Appliance system is a one-node system, which uses one server to transfer data from the backup server to the storage fabric, as shown in Figure 11-16.

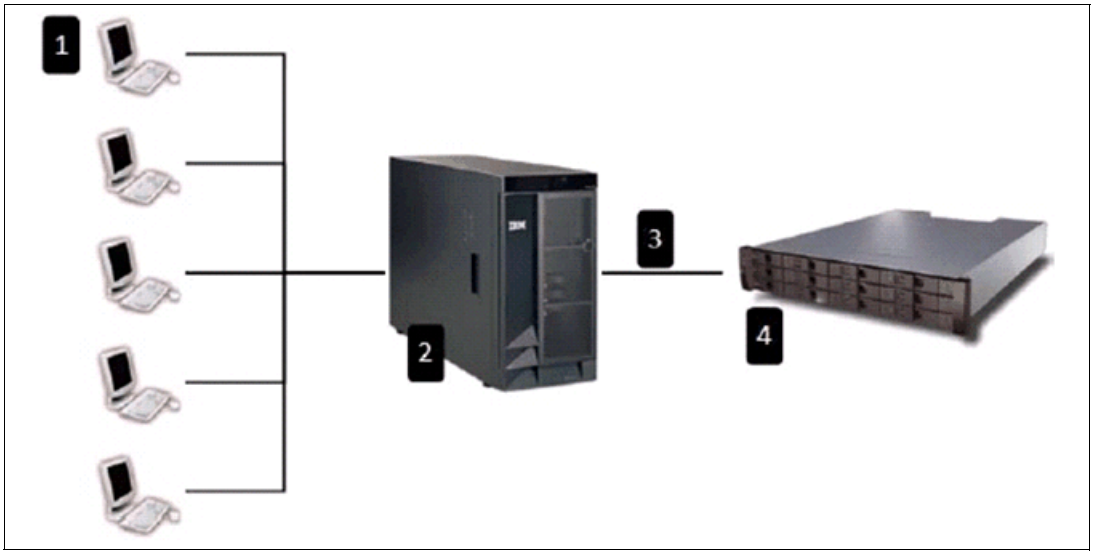


Figure 11-16 A typical TS7620 one node ProtecTIER system deployment

Figure 11-16 shows the following TS7620 components:

1 Backup client/server (supplied by client)

2 Main backup server (supplied by client)

3 Fibre Channel cable connections (not included in ProtecTIER package)

4 TS7620 SMB Appliance

Within the TS7620 appliance, you can define the following components:

- Up to 4 x TS3500 virtual tape libraries
- Up to 64 x LTO-3 virtual tape drives
- Up to 8,012 virtual cartridges
- Up to 1,022 import export slots

The TS7620 VTL appliance is shipped with the following software configurations:

- A TS3500 virtual library
- 16 LTO-3 virtual drives, balanced evenly across both FC ports
- 200 GB cartridge size
- 16 virtual import export slots
- The Small model has 400 virtual slots and 400 virtual cartridges
- The Medium model has 540 virtual slots and 540 virtual cartridges

You can modify the configuration according to your own requirements when you must add more tape libraries, tape drives, cartridges, and slots.

11.6 ProtecTIER VTL

As shown in Figure 11-17, the ProtecTIER VTL emulates traditional tape libraries. By emulating tape libraries, ProtecTIER enables you to migrate to disk backup without having to replace your entire backup environment. Your existing backup application can access virtual robots to move virtual cartridges between virtual slots and drives. The backup application perceives that the data is stored on cartridges while ProtecTIER actually stores data on a deduplicated disk repository on the storage fabric or direct attached storage.

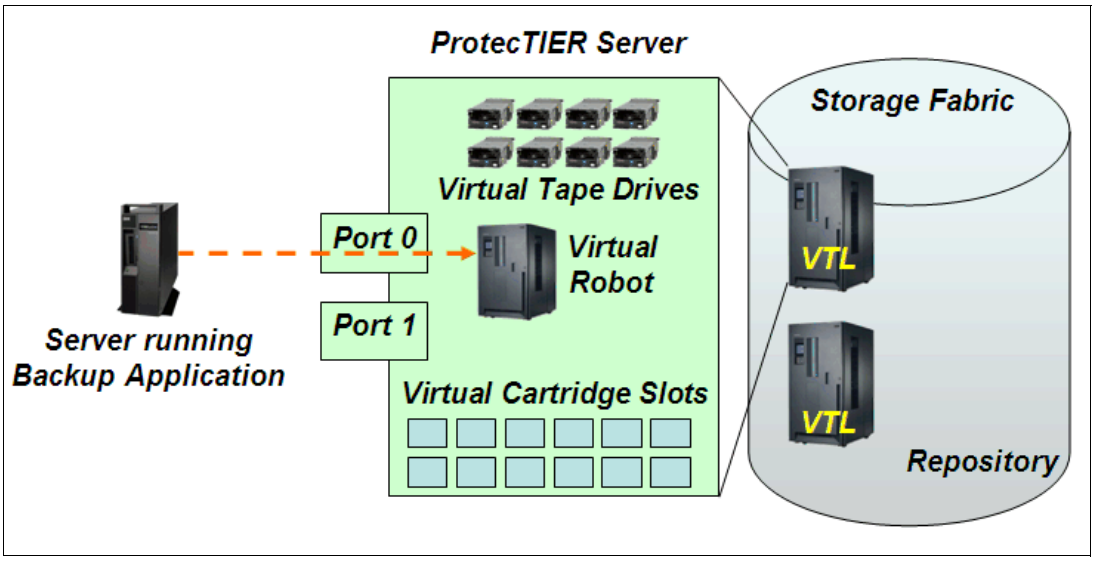


Figure 11-17 ProtecTIER Virtual tape library

11.6.1 ProtecTIER VTL concepts

After the data is loaded, the ProtecTIER VTL functions like a traditional VTL with the addition of the deduplication processing requirements.

When duplicate data is identified by ProtecTIER, it updates a reference count in the database. ProtecTIER uses the reference count to determine when a data segment can be overwritten (deleted). As shown in Figure 11-18, sector 3 represents a segment that occurs four times within the virtual cartridges in the repository. In the lower left corner is a representation of the reference table that shows that sector 3 is referenced four times.

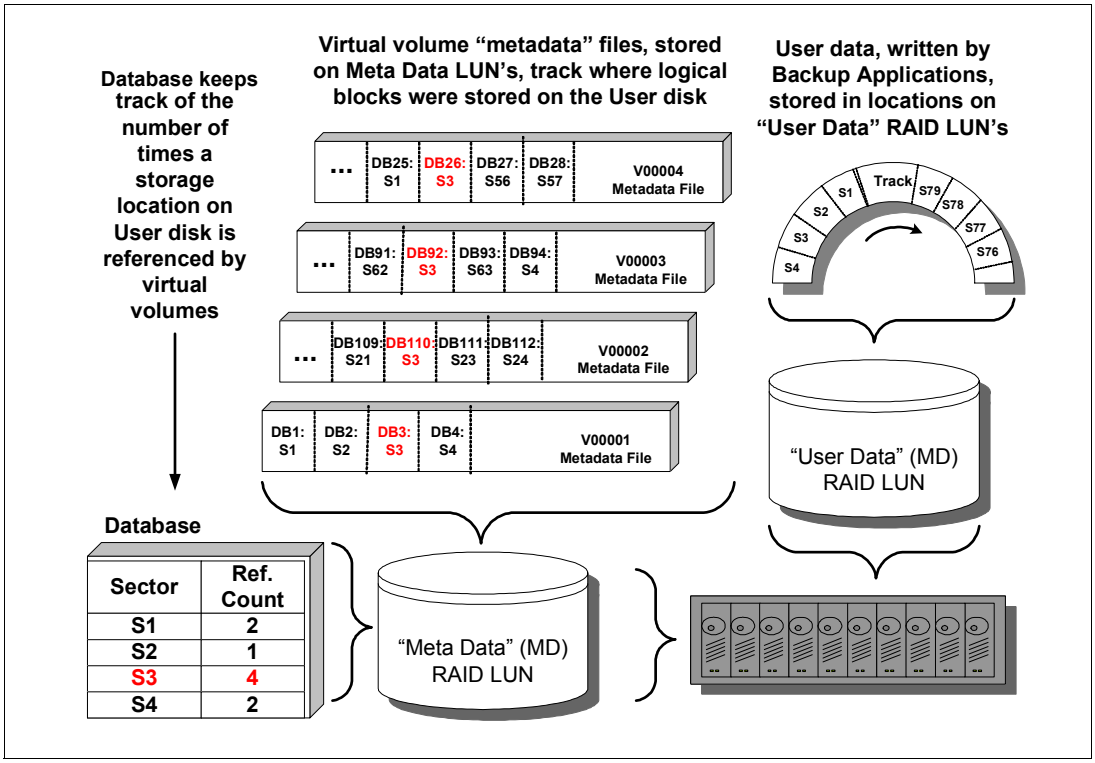


Figure 11-18 ProtecTIER virtual tape library concepts

ProtecTIER uses the metadata files to read back the virtual cartridges. When a virtual cartridge is overwritten or deleted, the reference count for each segment of user data on a virtual cartridge is decremented. When the reference count reaches zero, the space that is occupied by that user data segment is released. Virtual cartridges behave differently from physical ones. Their maximum size can be set manually or it can be left to ProtecTIER to dynamically size them based on repository size, the number of cartridges, and the deduplication ratio.

ProtecTIER uses the Global File System (GFS) to allow multiple references to the same data.

11.6.2 Steady state

After ProtecTIER is operational for some time, it reaches *steady state*. The point at which steady state is reached varies based on the size of the cache and the frequency of backups. To understand the concept, it might help to think in terms of a real physical library. In those terms, a physical library reaches steady state when all cartridges are used, but enough cartridges become scratch every night to provide the media that is required for the next day's backup.

In that context, if you allow ProtecTIER to decide how much data fits on every cartridge and you accurately predicted the factoring ratio, you use the last of the usable space in the repository when you fill the last available scratch cartridge.

Until all available scratch cartridges are used, ProtecTIER only performs two types of input/output to the RAID. While doing backup, it is performing random reads to the user data disk to prove the duplicate data (90%) and it is performing writes of new user data (10%). As that backup data is written to the user data disk, ProtecTIER also is performing roughly 90% random write I/O to the metadata logical unit numbers (LUNs), as it updates the virtual cartridge metadata files to record where the user data is stored for each virtual cartridge.

After the system enters steady state, ProtecTIER is managing four types of I/O activity to the disk: the two types of I/O performed as all virtual cartridges were filled (standard backup activity, as described previously), plus the following new work:

- Reading and deleting old metadata files
- Moving data from fragmented block groups to free space in block groups

To prevent the defragmentation operations from affecting performance, they are only allowed a maximum of 15% of the total input/output operations per second (IOPS) of the system.

From a performance standpoint, when the ProtecTIER system first begins ingesting data, it is not matching new data to existing data and no fragmentation is occurring. This enables high performance. When steady state is achieved, performance stabilizes. Figure 11-19 is a conceptualization of the performance from initial implementation through steady state. The change in performance and the time to reach steady state depend on the size of the repository and the operational characteristics of your data.

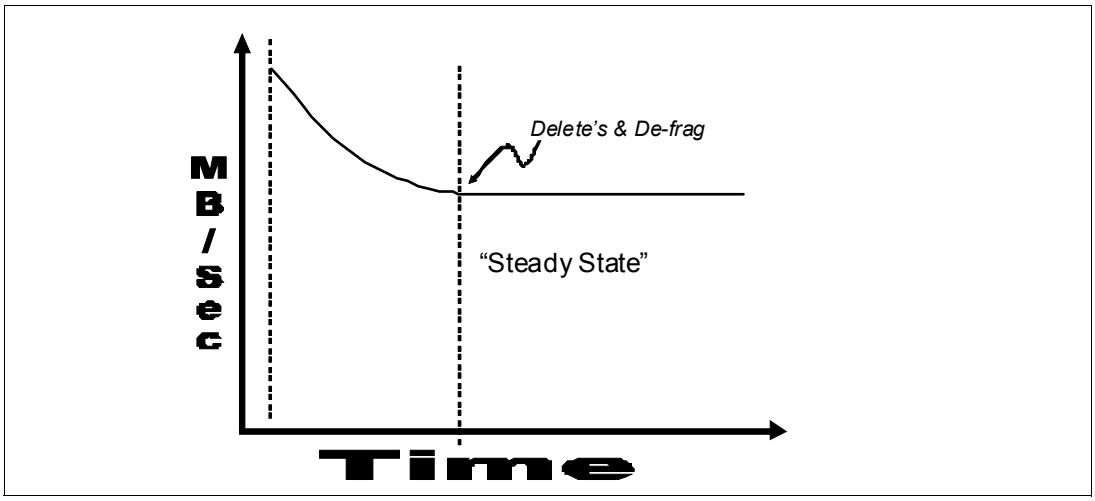


Figure 11-19 ProtecTIER performance from initial implementation through steady state

11.7 ProtecTIER OpenStorage

With OST, ProtecTIER can be integrated with NetBackup to provide the means for backup-to-disk without having to emulate traditional tape libraries. By using a plug-in that is installed on an OST-enabled media server, ProtecTIER can implement a communication protocol that supports data transfer and control between the backup server and the ProtecTIER server. Therefore, to support the plug-in, ProtecTIER implements a storage server emulation, as shown in Figure 11-20 on page 386.

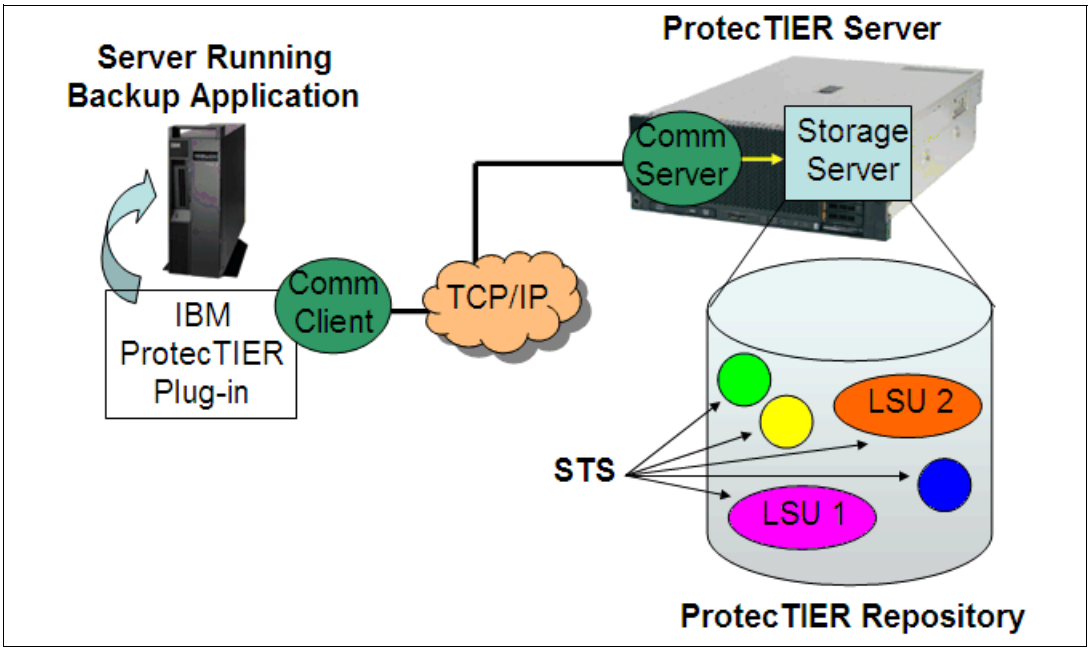


Figure 11-20 OpenStorage emulation

The OpenStorage interface is a NetBackup appliance programming interface (API) that supports communications between NetBackup systems and OpenStorage-enabled ProtecTIER systems. The OpenStorage interface provides the following capabilities:

- NetBackup software directs ProtecTIER systems when to create, copy, delete, or restore backup images.
- Backup images can be replicated to up to 12 different ProtecTIER systems.
- Workloads and performance are balanced between NetBackup media servers and ProtecTIER systems.
- Detailed statistics on the state of the ProtecTIER systems are available through API.

Important: OST supports many-to-many bidirectional replication with up to 12 systems in a hub mesh group.

ProtecTIER V3.2 OST and up can be connected by using 10 Gb NIC cards. Many environments are adopting 10 Gb Ethernet infrastructures. As a result, it is necessary to provide 10 Gb Ethernet connectivity to ProtecTIER systems that use the OST interface.

Important: 10 Gb copper is not supported.

10 Gb can only be used for the optical interface and only on the TS7650 gateway server.

11.8 ProtecTIER FSI

This topic provides a general introduction for the ProtecTIER FSI. The ProtecTIER FSI emulates UNIX or Windows file system behavior and presents a virtualized hierarchy of file systems, directories, and files to UNIX NFS and Windows CIFS clients. Clients can perform all UNIX and Windows file system operations on the emulated file system content. The ProtecTIER FSI interface is intended to be used for backup and restore of data sets that use a backup application.

Support for primary storage: Use of the ProtecTIER FSI interface for primary storage is not supported as of this writing.

With FSI, ProtecTIER emulates a network-attached storage (NAS) backup target that uses HyperFactor and ProtecTIER Native Replication bandwidth reduction techniques for storing and replicating deduplicated data. ProtecTIER FSI enables backup servers running backup applications to connect over IP networks to ProtecTIER, without the use of FC connectivity and allows clients to use their existing tools and capabilities to integrate a ProtecTIER NAS-based backup target into your environment.

ProtecTIER can work in Active Directory mode or in Workgroup mode for Windows systems. In the Active Directory mode, the ProtecTIER system joins the domain that is defined by the user. The domain users can work with the file systems, assuming that they are authenticated by the active directory server. In Workgroup mode, the ProtecTIER system manages the users that can access the file systems. You must define the users through the ProtecTIER Manager.

Important: The use of the ProtecTIER FSI as an NAS or Scale Out Network Attached Storage is not supported.

FSI is available for new installations only on the following platforms: DD5, DD4, AP1 (DD4 based), and SM2.

FSI features the following scalability specifications:

- Maximum file systems per repository: 128

  4 on SM2
- Maximum nominal file system size: 256TB
- Maximum files per file system: 1 million
- Maximum files per repository: 16 million

  4 million on SM2
- Maximum “open files” per repository (streams): 256
  - 128 on AP1
  - 64 on SM2

11.8.1 FSI Replication

FSI Replication enables directory replication capability across repositories between ProtecTIER nodes that are connected to the same WAN. Many-to-many topology is supported with up to eight bidirectional servers in a grid with up to three target destinations for each source, as shown in Figure 11-21. The replication target is a directory on the remote repository file system Remote Destination Directory (RDD). An RDD is dedicated to a source repository and a certain policy. An RDD can be shared by read-only user permission. Replication can be triggered manually or by policy.

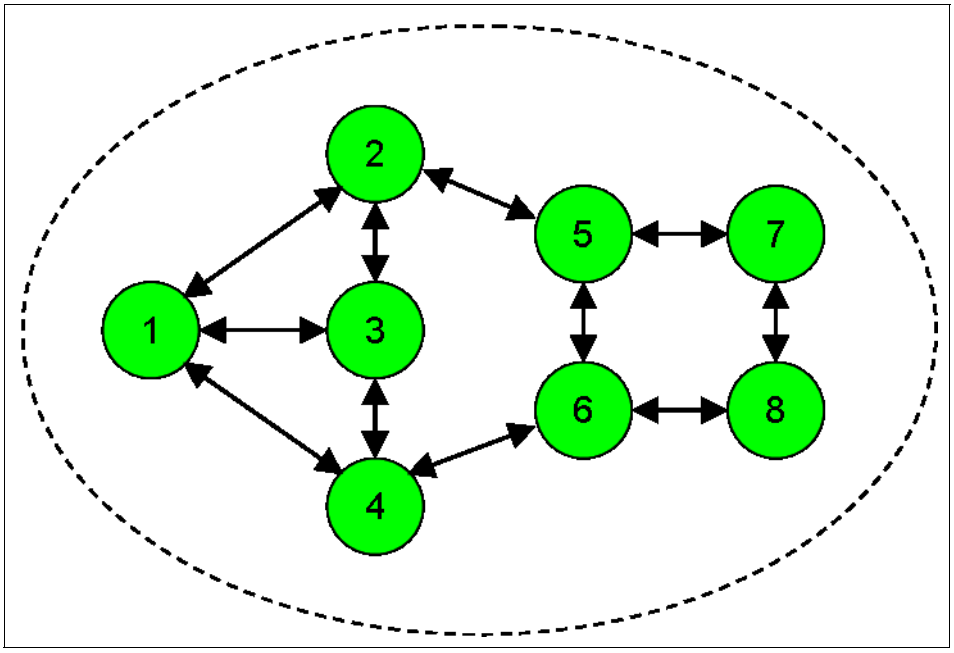


Figure 11-21 FSI replication example

11.9 Initial configuration of TS7600

The different IBM TS7600s with ProtecTIER are loaded and preinstalled with the code level ProtecTIER V3.3. The initial configuration process appears to be different between the TS7600 systems. While the IBM TS7620 ProtecTIER Deduplication Appliance Express and the IBM TS7650 ProtecTIER Deduplication Appliance are preinstalled and preconfigured, the nodes of the IBM TS7650G ProtecTIER Deduplication Gateway come preinstalled. Therefore, the initial configuration must be performed on the TS7650 Gateway, whereas the TS7650 Appliance and TS7620 Appliance Express need changes only in the configuration.

The TS7650 gateway system needs different steps of configuration than the TS7620 or TS7650 appliance systems. The ProtecTIER software is installed on the delivered nodes but unconfigured. Therefore, the initial configuration must follow a different procedure.

For more information about ProtecTIER configuration, see *IBM System Storage TS7600 with ProtecTIER Version 3.1,* SG24-7968. The different models are described in the next sections.

11.9.1 Initial configuration of TS7620 appliance

The IBM TS7620 ProtecTIER Deduplication Appliance Express (TS7620 Appliance) is a customer-installable data deduplication and replication solution. The system is already loaded with ProtecTIER version 3.3 and preconfigured on some level by manufacturing.

The TS7620 VTL appliance is shipped with the following preconfigured software:

- A TS3500 virtual library
- 16 LTO3 virtual drives, balanced evenly across both FC ports
- 200 GB cartridge size
- 16 virtual import export slots
- The Small model will have 540 virtual slots and 540 virtual cartridges
- The Medium model will have 1100 virtual slots and 1100 virtual cartridges

The TS7620 OST appliance is shipped with the software preconfigured for one Storage Server (STS) but no Logical Storage Units (LSU). You must configure the LSUs as needed for your environment.

Important: You must install the OST plug-in on the NetBackup servers which are using the TS7620 SM2.

The TS7620 FSI is shipped with the software preconfigured, so you can start adding directories as needed.

You can modify the configuration according to your own requirement when you must add more tape libraries, tape drives, cartridges, and slots for VTL or LSUs for OST and Directories for FSI. The initial configuration consists only of the following settings:

- Specify the IP address of a primary (and optional secondary) network time
- Protocol (NTP) time server, if applicable
- Set the time zone to that of your location
- Check (and update, if necessary) the time and date settings
- Update the system, external (customer) network, and PT application interface; settings
- Configure alerts, Call home

When you first log in to the PT Manager, you see a message display for starting the configuration of the SM2.

Initial configuration TS7650 Appliance

This solution cannot be ordered as of November 30, 2012. The IBM TS7650 ProtecTIER Deduplication Appliance is a preconfigured Virtualization solution that improves backup and recovery operations. The solution is available in four configurations that meet the disk-based data protection needs of various organizations, from mid-sized IT environments to enterprise data centers. The system already is loaded with ProtecTIER version 3.3 and preconfigured on some level by manufacturing.

It is preconfigured up to the point that a repository is available for use and depending on the system, you can create your wanted environment (VTL, OST, or FSI). You also need to complete the following setup:

- Specify the IP address of a primary (and optional secondary) network time
- Use the Network Time Protocol (NTP) server, if applicable

- Set the time zone to that of your location
- Check (and update, if necessary) the time and date settings
- Update the system, external (customer) network, PT application interface, and settings
- Configure alerts and Call home

11.9.2 Initial configuration of the TS7650 gateway

The IBM TS7650G is a preconfigured virtualization solution of IBM systems, and the IBM revolutionary ProtecTIER data deduplication software improves backup and recovery operations. The solution is available in a single node or two node cluster configurations that meet the disk-based data protection needs of various IT environments enterprise data centers organizations.

The TS7650G comes preinstalled with the ProtecTIER server software. It does not have disk storage included (it must be purchased separately) or you can use one of your own. You must complete the following tasks:

- Assign disk storage to the ProtecTIER servers
- Install ProtecTIER server software
- Create filesystems on ProtecTIER
- Create repository
- Set up cluster if applicable
- Specify the IP address of a primary (and optional secondary) network time
- Protocol (NTP) time server, if applicable
- Set the time zone to that of your location
- Check (and update, if necessary) the time and date settings
- Update the system, external (customer) network, and PT application interface; settings
- Configure alerts, Call home

After the initial setup is done, you can configure your system according to your hardware setup (VTL, OST, or FSI).

11.10 ProtecTIER Manager

The ProtecTIER Manager (PT Manager) application is a graphical user interface (GUI) that is used to view, configure, manage, upgrade, and troubleshoot the operation of the IBM TS7600 family products. You can monitor the status of nodes and two-node clusters in your ProtecTIER system and the accompanying repositories and services. PT Manager is used to initially configure your ProtecTIER system. It can be installed on a workstation that is in the user network that is configured on the TS7600 during installation. The PT Manager does not need to be located near the ProtecTIER system when TCP/IP connectivity to the ProtecTIER system is allowed.

The PT Manager workstation is a designated Windows or Linux-based workstation on the user network that run the PT Manager GUI.

Important: You cannot use a TS7600 server as the PT Manager workstation. You must use a workstation that is running Windows or Linux. Also, if you use a Linux-based workstation, it must have a Linux GUI installed. The PT Manager also can be installed on the TSSC.

The workstation for the installation of the PT Manager is not included in the ProtecTIER system. You can install the PT Manager GUI on any workstation that meets the following requirements:

- x86 (Pentium or higher) microprocessor
- 256 MB memory at minimum
- 1.2 GB of disk space
- Access to the ProtecTIER service node's IP address (port 3501 and 3503 are open on the firewall)
- Keyboard, mouse, and CD-ROM drive
- Screen resolution of 1024 x 768 or higher
- 24-bit color or higher
- Operating environments supported:
  - Windows 32/64 bit (2003, XP or 7)
  - Linux Red Hat 32/64 bit (Enterprise 4 or higher)

Important: If you are planning to run PT Manager on a UNIX system, configure your graphics card and X Window System system. This is done manually or by using the Xconfigurator utility. For more information, see the appropriate Linux documentation.

The console hardware is not included in a TS7600 family order. You can order the console hardware that meets the specifications from IBM or use an existing workstation that meets these minimum specifications.

Figure 11-22 on page 392 shows three VTLs that are on the single node system called Hungary. You can see that there are three VTLs defined in the repository with 64 virtual drives. You can view more details about the library by selecting it and then selecting the Drives, Cartridges, Slots, or Import/Export tabs at the top of the view.

For more information, see *IBM System Storage TS7600 with ProtecTIER Introduction and Planning Guide*; for the appliance products TS7620 and TS7650, see GA32-0918; for the TS7650 gateway product, see GA32-0919.

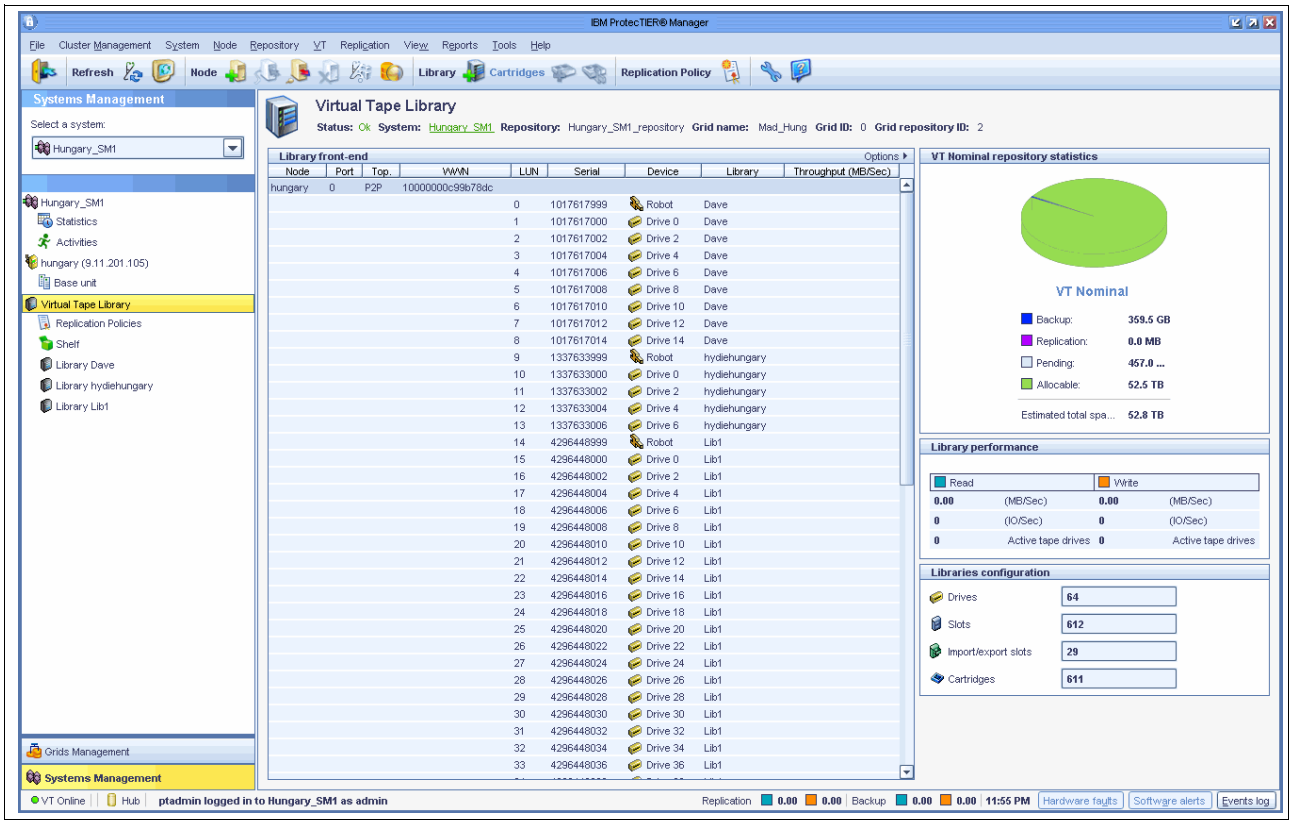


Figure 11-22 ProtecTIER Manager library summary view

You might modify your configuration according to your current requirements. This includes creating libraries, deleting libraries, changing library dimensions, setting capabilities (like compression and Hyperfactor). You can unload drives, reset drives, and perform various tasks on cartridges (for example, add, eject, delete). For more information, see *IBM System Storage TS7600 with ProtecTIER v3.2 User's Guide*, GA32-0922.

11.10.1 ProtecTIER native replication Management Interface

The ProtecTIER native replication Management Interface provides an option-rich platform and is easy to use. It performs the following tasks:

- Defines policies and assigns priorities (see Figure 11-23).
- Chooses the cartridges to be replicated.
- Schedules the replication window; the time frame replication takes place for all policies.
- Defines the following cartridge visibility features:
  - Determines where virtual cartridges exist from ProtecTIER or a backup application standpoint.
  - ProtecTIER native replication emulates moving tapes in and out of VTL's import/export slots.
  - Allows users to use the VTL export/import slots via the backup application to change the visibility of the cartridges from one library to another.

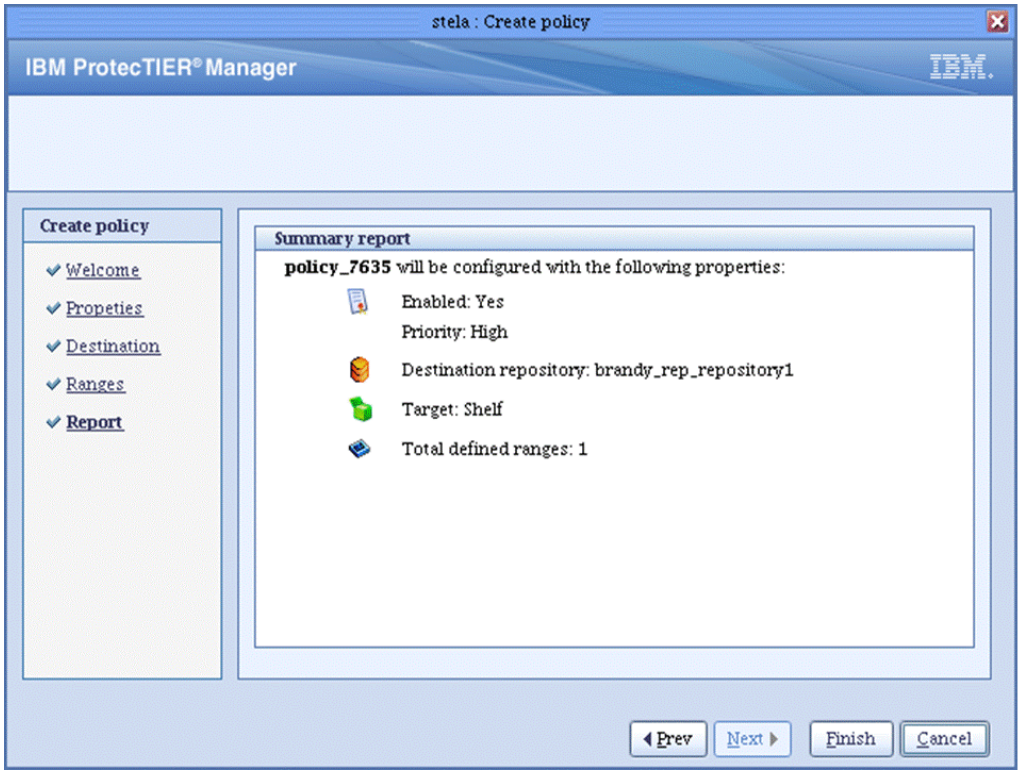


Figure 11-23 Replication policy

11.11 Set up the virtual library and cartridges

By using the ProtecTIER system, you can create VTLs where the backup application stores your data. These libraries and their components are part of the virtual tape service.

11.11.1 Creating libraries

A library can be created on a ProtecTIER system of a one-node cluster or a two-node cluster. By default, the TS3500 tape library is selected. The functionality of the TS3500 tape library and the IBM V-TS3500 is the same. The following types of library are supported by ProtecTIER:

- Emulation of the TS3500 tape library with IBM LTO Ultrium 3 tape drives
- Emulation of the Quantum p3000 tape library with DLT7000 tape drives or IBM LTO Ultrium 2 tape drives
- Emulation of the DTC VTF 0100 virtual tape libraries with DLT7000 tape drives or IBM LTO Ultrium 2 tape drives

Important: Verify that the backup application that you are using supports the type of library model that you want to use.

If you are using Symantec NetBackup software, you should use V-TS3500.

If you are using Tivoli Storage Manager software, you should use TS3500 tape library.

For high-availability reasons, the IBM TS7600 with ProtecTIER supports the assignment of the virtual robot to multiple ports. Check with your backup application administrator to ensure the number of drives and cartridges that are supported by your application. The maximum number of tape drives per ProtecTIER node is 256, as shown in Table 11-6.

Table 11-6 Maximum number of libraries and drives allowed

	TS7620 Appliance	TS7650 Appliance	TS7650G
Maximum number of libraries	4	12	16
Maximum number of drives	256	256 (dual-node 512)	256 (dual-node 512)
Maximum number of virtual cartridges	8192, see note below	128,000, see note below	512,000, see note below

Important: The maximum number of cartridges possible on a system depends on the amount of storage space that is available on your system. The maximum size for virtual cartridges is based on the number of cartridges entered, the total amount of available storage space in your repository, and the current HyperFactor ratio.

Complete the following steps to create a library:

1. Select **Create new library**.
2. Name the new library.
3. Select the type of the VTL.
4. Choose the drive model, (if possible) and the number of drives.
5. Set the drive and robot distribution among ProtecTIER front-end ports.
6. Define the cartridge amount, size, bar code seed, and number of storage slots.

The ProtecTIER system temporarily goes offline to create the library.

The newly created library is displayed in the left panel. The right panel shows the details of the virtual library you created, as shown in Figure 11-24.

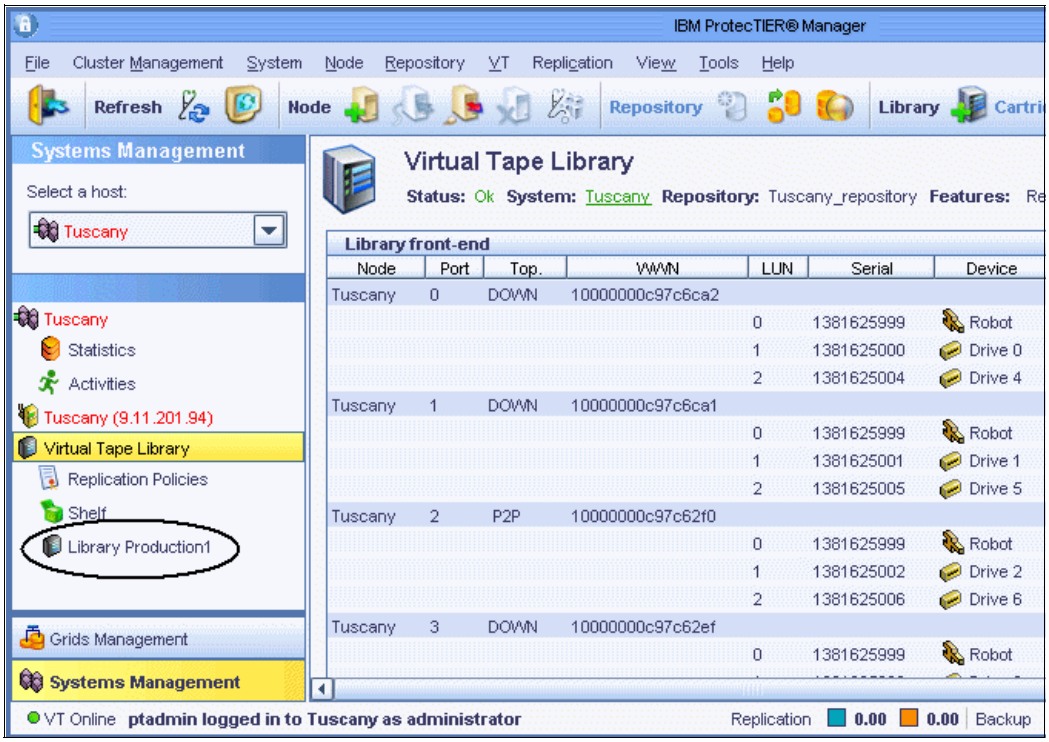


Figure 11-24 New virtual tape library created

For more information, see *IBM System Storage TS7600 with ProtecTIER v3.2 User's Guide*, GA32-0922.

11.12 ProtecTIER SNMP support

ProtecTIER responds to SNMP, implementing MIB-2, and generating the appropriate traps. The server responds to SNMP discovery and queries and to the standard MIB requests.

11.12.1 IBM MIB definition file

IBM supplies an MIB definition file called `DILIGENT-MIB.txt` that is in the `/usr/share/snmp/mibs` directory of the TS7650G or TS7650 AP1. This file describes each of the supported traps and should be imported into the SNMP application that is used at the client site.

For the TS7620 (3959 SM2 server), the MIB file names are `DILIGENT-MIB.txt` and `IBM-TS-RAS-MIB.txt`. The files are in the `/usr/share/snmp/mibs` directory.

11.12.2 SNMP compatibility

ProtecTIER includes the following SNMP implementations:

- MIB implementation

  In the MIB-2 System Group, the following fields are implemented:

  - sysDescr
  - sysObjectID
  - sysUpTime
  - sysContact
  - sysName
  - sysLocation
  - sysServices

  All other parts of the MIB-2 respond in such a way that management tools understand that they are not implemented.

- Traps

  The following traps are generated:

  - coldStart
  - warmStart
  - authenticationFailure
  - operatorInterventionRequired (proprietary)
  - recoverableErrorNotification (proprietary)

  If authentication of a user fails more than five consecutive times, an SNMP authenticationFailure trap is generated.

- Startup consistency checks

  ProtecTIER checks its persistent data on startup by using a Power On Self-Test (POST) procedure to verify that the application can run. Initialization files are checked for consistency. Resource allocation (specifically, memory) is checked.

  Errors encountered might be recoverable or unrecoverable.

  A recoverable error is an error that the ProtecTIER system can recover without losing the user's data. Recoverable errors are logged in the ProtecTIER logs and generate an SNMP warning notification trap.

  An unrecoverable error is an error that prevents the platform from booting correctly, an unrecoverable consistency check error during ProtecTIER server startup, or any other error that might cause or did cause loss of user data. The server is left in an offline state (booted, responding to TCP/IP SNMP inquiries, and responding to console, Telnet, and modem login). Unrecoverable errors are logged in the ProtecTIER logs and generate an SNMP error trap.

- Restarting on error

  If the ProtecTIER server detects an error at run time, it recovers by rebooting and restarting the ProtecTIER process. If multiple restarts are detected within a short time, the ProtecTIER server declares an unrecoverable error.

- Alerts

The server generates SNMP traps to higher-level management frameworks. In particular, whenever the system enters the online state, it generates a coldStart trap if the platform

reboots, and a warmStart trap if the system only returned to the online state from the offline state. A recoverable error generates a recoverableErrorNotification trap. An unrecoverable error generates an operatorInterventionRequired trap.

11.13 Replication overview

ProtecTIER with replication enables virtual tape cartridges to be replicated from the primary site to a secondary location for enhanced disaster recovery (DR) and business continuity (BC) capabilities. By eliminating the need to transport physical tape cartridges, data can be recovered faster and more reliably, which enables you to get back online sooner in the event of a disaster or major system outage. The dramatic reduction in the required network bandwidth between the primary and secondary sites enabled by ProtecTIER's deduplication technology radically reduces the costs that are associated with electronically transmitting data to a remote location for disaster recovery purposes.

By reducing costs, ProtecTIER with replication enables IT organizations to easily expand the coverage of replication to all of the applications in their environment, as opposed to deploying replication for only a select few applications and tolerating significant risks of data loss and slow recovery for most other applications. Figure 11-25 shows the prohibitive costs of traditional replication, and contrasts this to the increased level of DR protection that is enabled by ProtecTIER. Figure 11-25 represents a generic IT environment where the cost to protect 30% of their data with traditional replication is equal to the cost of covering 100% of the data with ProtecTIER replication.

Important: This chapter describes the replication for VTL. OST and FSI also have replication capabilities available.

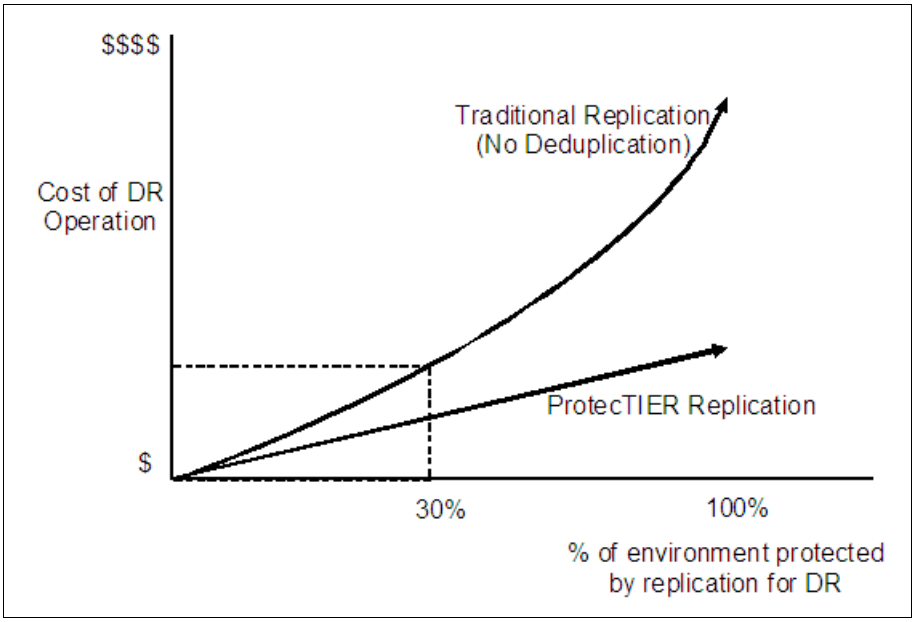


Figure 11-25 Relationship between cost and percent of environment protected

11.14 How it works

Replication is another feature that is built into the VTL so that you can pick and choose some or all of the cartridges that are to be replicated to the DR site. Because ProtecTIER deduplicates data before storing it, only the changes, or unique elements of data, are transferred to the DR site over the replication link. This translates into substantial savings in the bandwidth that is needed for the replication link. Data transfer is started based on several trigger points, such as policy-based transfer windows, or movement of the virtual tape to a VTL export slot (the VTL emulates import and export slots, and opening/closing of the library door to insert or eject a cartridge). Data verification and validation is done at the DR site to ensure integrity of the transferred data before making the virtual cartridge or tape available. Figure 11-26 is an example of a deployment for two systems that use replication.

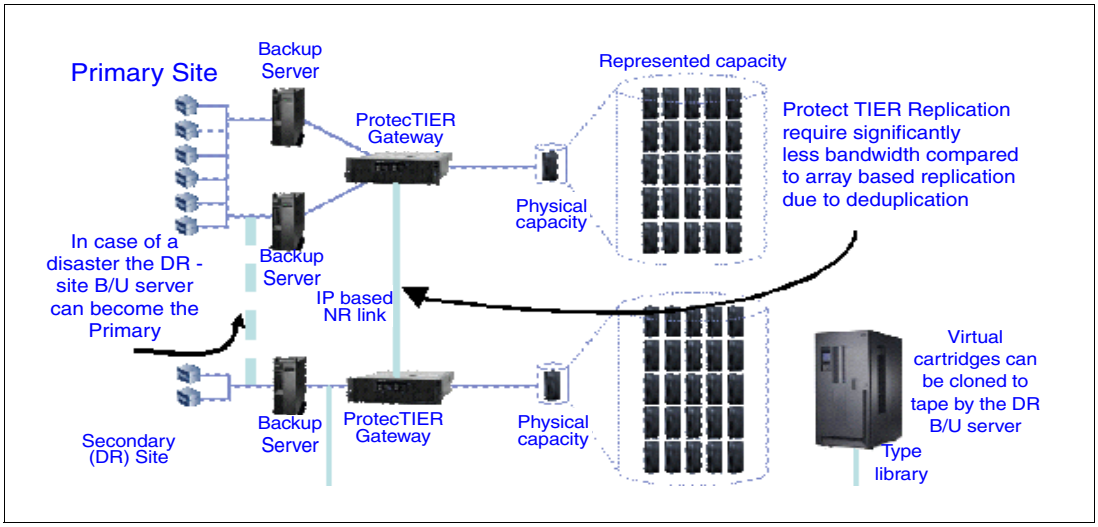


Figure 11-26 Typical deployment for two systems that use replication

11.14.1 Replication features

ProtecTIER's replication provides you with great flexibility, works seamlessly with any of the leading backup applications, and fits easily within the overall tape operations paradigm. Replication is policy-based, which allows you to define several policies for replicating cartridges from one system to another. Because of the granularity of the replication policies, you can set policies for an individual cartridge, a pool of cartridges, or an entire VTL. Replication is performed asynchronously at the logical cartridge level. Replication progress can be tracked and monitored at the cartridge level through the ProtecTIER management GUI. Full data validation is performed at the secondary site to ensure enterprise-class integrity of the transferred data before making the virtual cartridge available. After it is replicated to the DR site, you might choose to clone these cartridges to real physical tape by using their backup application. In the event of a disaster, the DR site's TS7650 or TS7650G can become the production site until the main site comes back online. At that point, you can replicate or move the newly created tapes back to the main production site.

In the following sections, wed describe a few of the key features and design points that demonstrate the flexibility and synergy with the tape operations paradigm.

Virtual tape management framework

As a target of the backup application, a ProtecTIER system presents itself as a tape library (or many libraries) to the network. The backup application manages the cartridges within a ProtecTIER system as though they were real cartridges, including read, write, import/export, tracking media with bar codes, and many other operations. Because replication at the ProtecTIER level is not apparent to the backup application, ProtecTIER's replication function allows synchronization with the backup application by way of normal tape management methodologies.

Shelf

The ProtecTIER replication feature introduces the concept of a virtual shelf. As a general rule, replication always occurs from the source shelf to a destination shelf. As with physical tape shelves, there is a limit to the number of tapes that can be put on a virtual shelf. The limit is the result of subtracting the total number of tapes in all libraries from the total number of tapes that are supported in a single repository.

Visibility switch control

Visibility switch control is the means by which ProtecTIER can determine where cartridges actually exist, because from a backup application standpoint, any specific cartridge or bar code can exist in only one location at a time. ProtecTIER native replication provides a virtual shelf (see Figure 11-27) that is visible internally only at the ProtecTIER level (after it is exported by the backup application). It also provides more flexibility in managing tapes and cartridges and where they are kept, similar to keeping physical tapes on an actual shelf outside of the tape library.

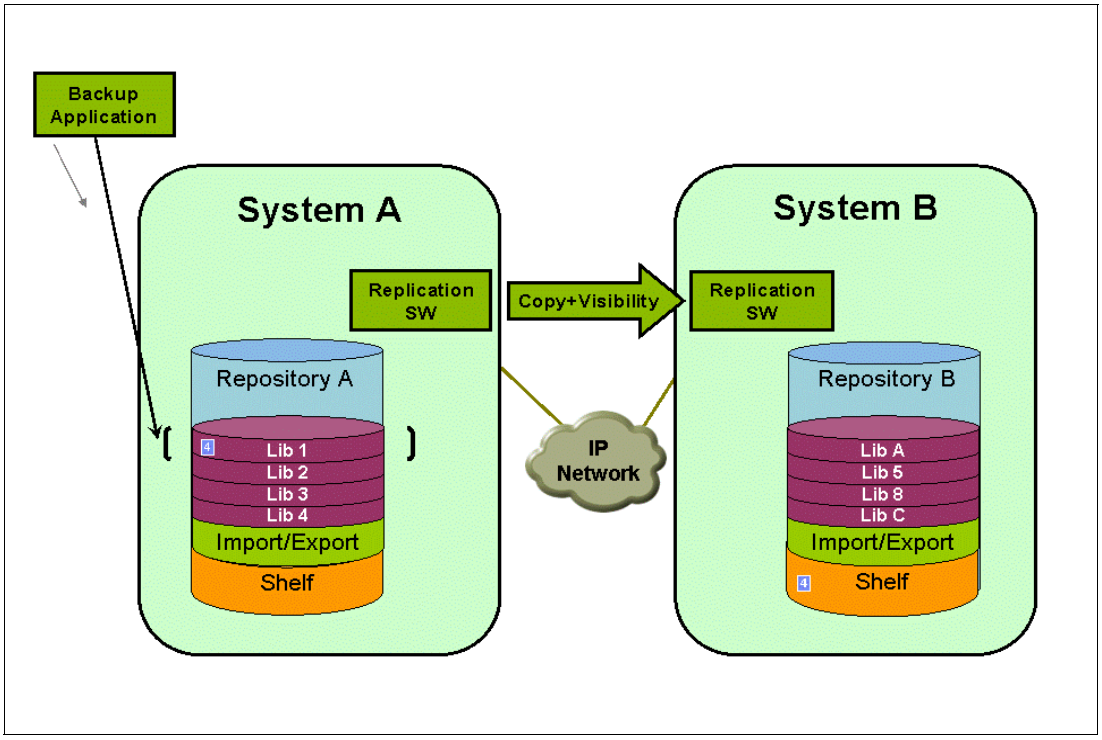


Figure 11-27 Virtual shelf

To ensure that a given cartridge is visible only to the backup application in one location despite the fact that a replica exists, ProtecTIER offers the visibility control function. By using this function, you can determine at which location the cartridge should be accessible by the backup application. This is achieved by using the import/export slots of the virtual libraries, which mimic exactly the operation of physical tape management.

Replication visibility is an attribute that is defined in a replication policy and can be set by you. A specifically defined library in the remote repository must be selected for the visibility transfer to be carried out. After the cartridge is ejected at the primary (local) site, it moves to the local virtual shelf. Then it is replicated as part of a policy to the remote site virtual shelf. After the replication is completed and verified, that replica moves to the respective library's import slot and can be imported into that library. At this point, that cartridge is visible only to the backup application at the remote site. A copy of the cartridge stays at the primary ProtecTIER system for fast recovery. However, it is hidden from the backup application. The way to move the cartridge back and make it visible to the backup application at the primary site is to eject it from the remote library and import it back into the local one (the same library from which it came). Because the system keeps a hidden copy at the primary site, this move back is instantaneous.

Cartridge cloning and visibility control

A common use case for ProtecTIER users is to first replicate data from the primary site to the secondary site, and then to move the data from the disk-based repository onto physical tape cartridges for long-term retention. With the visibility control function, ProtecTIER makes this operation simple for users. After the cartridges complete replication to the secondary (DR) site, you can clone these cartridges to physical tape by using their backup application tape copy function. This allows the backup application to remain in control of the end-to-end process and maintain its catalog of all cartridges, the associated data, and the location.

Policy management

Replication policies allow for flexibility in controlling replication and enabling a high degree of automation. Policies consist of rules that dictate the transfer of data from one repository to another, based on events such as writing new data to an existing cartridge that belongs to a policy. By setting policies for ranges of bar codes, users can implement differing degrees of protection for different applications. You also can assign various priority levels to replication policies, which determine the order the data is transferred across the network.

Replication network management

ProtecTIER repositories belong to a replication grid that is a framework for managing and monitoring the replication activities between ProtecTIER systems. Through ProtecTIER Manager, you can monitor the status of the overall replication network, the relationship between grid members, and the data throughput rate of replication. Further statistics about the cartridges that are involved in replication policies and the statistics of each repository are available in a single display from PT Manager to enable ease of management and use.

Recovery management

When the need to fail over to the second site arises, whether because of a full disaster or a lower-level disruption, the ProtecTIER system enables rapid recovery of the data and restoration of the production applications such that business operations can continue with minimal downtime. ProtecTIER enables rapid recovery of data from cartridges by using the media server at the remote site. After data is restored, the ProtecTIER system can be brought online as the production system and be used for backup and recovery until the primary site is restored.

During the time that the disaster recovery site acts as the primary production site, its data can be protected by replicating it to another secondary site. PT Manager should be used to pair the DR site (now acting as the primary) to the other secondary site. For more information, see Chapter 11, “Native replication and disaster recovery,” in *IBM System Storage TS7650, TS7650G, and TS7610*, SG24-7652, which is available at this website:

http://www.redbooks.ibm.com/

When ready, you perform a failback operation to move production activity back to the primary site. At that time, you might replicate any new data at the secondary site back to the primary and return the primary to its original status. All of these steps are enabled through the user interface.

11.14.2 Typical deployment

ProtecTIER native replication enables data replication capability across repositories, between ProtecTIER nodes that are connected to the same WAN. By using this WAN capability, you can replicate data at any distance to remote cities, states, territories, and so on, for the purposes of disaster recovery. The deduplication software, combined with replication, reduces the amount of bandwidth that is required.

ProtecTIER native replication provides high availability in accessing backed-up data for backup and restore operations across sites. By having a current copy of critical data in a remote site, along with a hot configuration of a TS7650 or TS7650G and your backup application ready to restore on a remote machine, data restoration can begin in a matter of minutes.

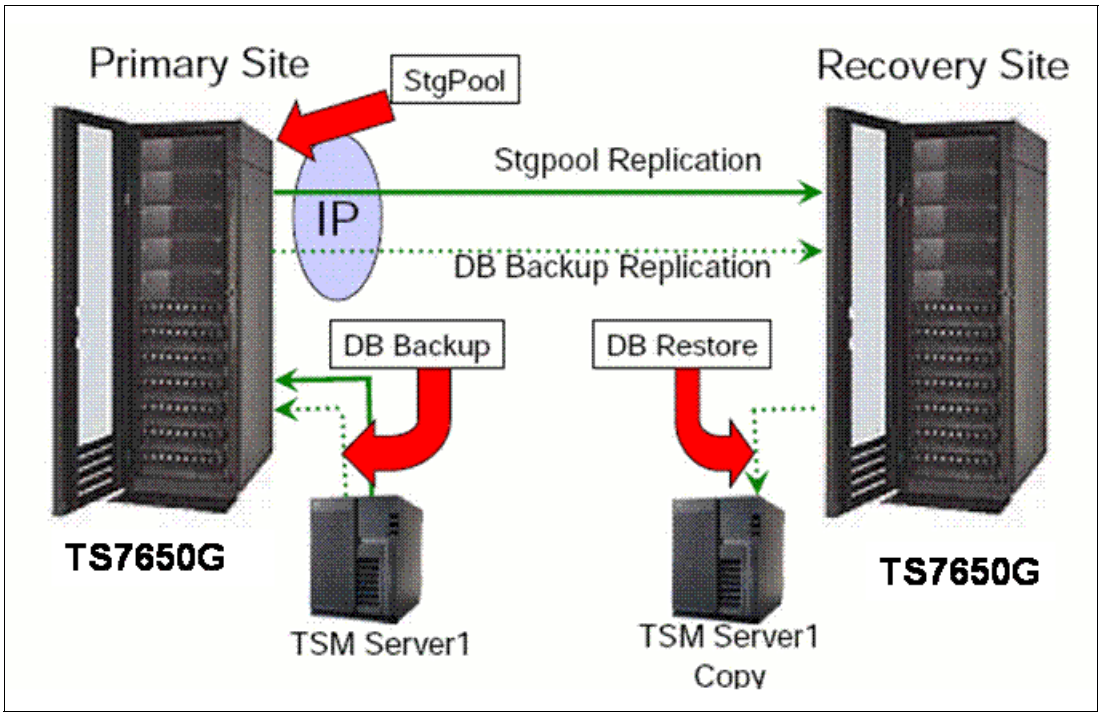


Figure 11-28 Back up applications by using replication

11.15 ProtecTIER native replication

Before the availability of ProtecTIER native replication, ProtecTIER users relied in most cases on disk array-based replication products. This meant that every changed disk block was replicated, even when it was only because of data scrubbing inside the ProtecTIER system. This eliminated a large portion of the ProtecTIER deduplication effect on the replication, and resulted in only a small amount of reduction in the amount of network bandwidth that is required compared with a first generation of VTL replication with no deduplication. Now, with ProtecTIER's native replication, only the changed elements of data (unique data) are transferred over the network, which results in a dramatic reduction in the bandwidth requirements.

The following types of native replication are available:

- Many-to-one replication: One hub can receive up to 12 spokes replication.
- Many-to-many replication: In a four-way group of ProtecTIER, you can replicate from one to each of three others, bidirectionally. This type of replication is available with ProtecTIER V3.1 software and above. For FSI, many-to-many topology is supported with up to eight bidirectional servers in a grid with up to three target destinations for each source.

11.15.1 Replication licensing

Replication licensing is done by capacity and varies slightly between the TS7600 family.

Replication licensing TS7650G

Replication is authorized by capacity corresponding to the total terabytes (TB) that are managed by the TS7650G. This entitles the client to use the replication functionality of ProtecTIER. It is required for every TS7650G that replicates data to another TS7600 family or receives replicated data from another TS7600 family. Terabyte capacity ordering is by cumulative tier. Starting with tier 1 (1 TB - 12 TB) up to tier 5 (more than 250 TB), order the quantity from each successive tier required to reach the total TB managed by the TS7650G, filling each tier in succession.

Replication licensing TS7650 Appliance

Replication is authorized by capacity corresponding to the total terabytes managed by the TS7650 Appliance. This entitles the client to use the replication functionality of ProtecTIER. It is required for every TS7650 Appliance that replicates data to another TS7600 family or receives replicated data from another TS7600 family. Terabyte capacity ordering is by cumulative tier. Starting with tier 1 (1 TB - 12 TB), order the quantity from each successive tier required to reach the total TB managed by the TS7650 Appliance, filling each tier in succession. Valid capacity values for the TS7650 Appliance are 7 TB, 18 TB, and 36 TB.

Replication licensing TS7620 SMB Appliance

Replication is authorized by capacity corresponding to the total terabytes managed by the TS7620 SMB Appliance. This entitles the client to use the replication functionality of ProtecTIER. It is required for every TS7620 SMB Appliance that replicates data to another TS7600 family or receives replicated data from another TS7600 family. Terabyte capacity ordering is by total appliance capacity, which can be 5.5 TB, 11 TB, 23 TB, or 35 TB.

11.15.2 Hardware

No other hardware is required for the 3958 DD3, 3958 DD4, 3958 DD5 Gateways, 3958 AP1 Appliance, or 3959 SM2 Appliance.

The physical replication grid includes the following characteristics:

- The replication grid is the container object for the ProtecTier one-node or two-node cluster systems.
- Each ProtecTIER two-node cluster has its own repository.
- The ProtecTIER two node clusters are connected via an IP-based WAN and exchange data, as shown in Figure 11-29.

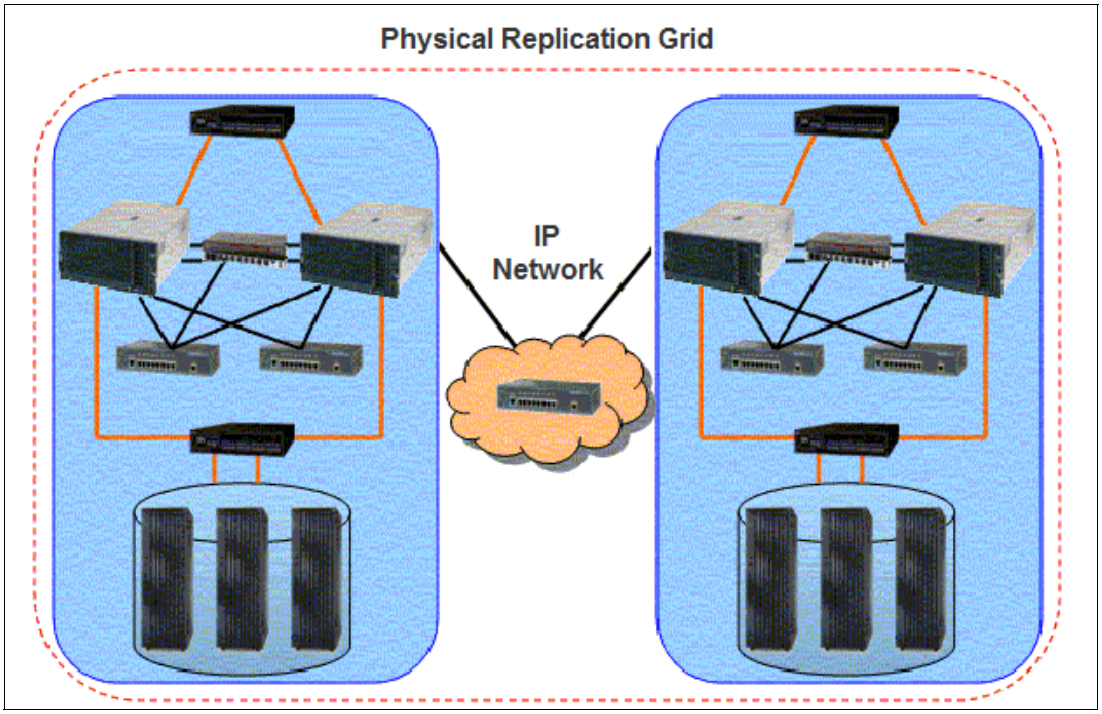


Figure 11-29 Physical Replication Grid

The following additions and changes are necessary to accommodate IP replication:

- Each site has a single node or two-node cluster ProtecTIER system.
- The TS7620 (SM2) has two dedicated Ethernet ports for replication, one onboard and one on another network interface card.
- The TS7650G (DD3, DD4 and DD5) and TS7650 (AP1) in a stand-alone configuration have two dedicated Ethernet ports for replication.
- The TS7650G (DD3, DD4 and DD5) and TS7650 (AP1) in a cluster configuration have four dedicated Ethernet ports for replication.
- Replication ports are connected to the customer's WAN.
- Replication ports are configured on two different subnets as the default.

11.15.3 Replication grid

A replication grid is a set of repositories that share a common ID and can potentially transmit and receive logical objects through replication. A replication grid defines a set of ProtecTIER repositories and actions between them. It is configured by using the ProtecTIER Replication Manager, which is a software component that is included with new orders of ProtecTIER V3.3. ProtecTIER Replication Manager (see Figure 11-30) and is activated on a ProtecTIER node.

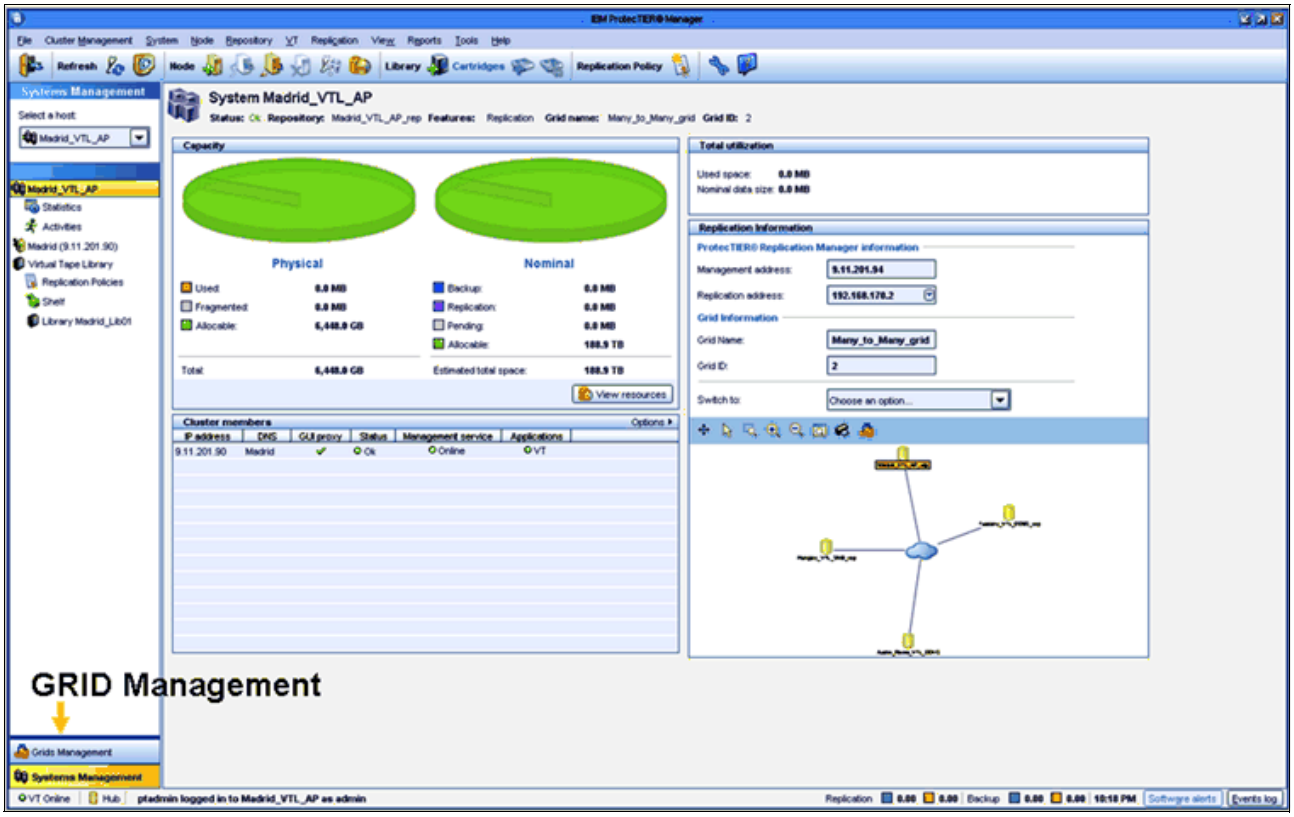


Figure 11-30 ProtecTIER Manager

Figure 11-31 shows an example of two ProtecTIER two-node clusters with a link between them. Each system comprises a repository that holds VTL and a shelf. A ProtecTier system holds CM Virtual Tape Facility Daemon (VTFD), and VTL services. Notice the introduction of a virtual shelf in Figure 11-31. One of the main uses of the virtual shelf is to receive replicated data from the source repository.

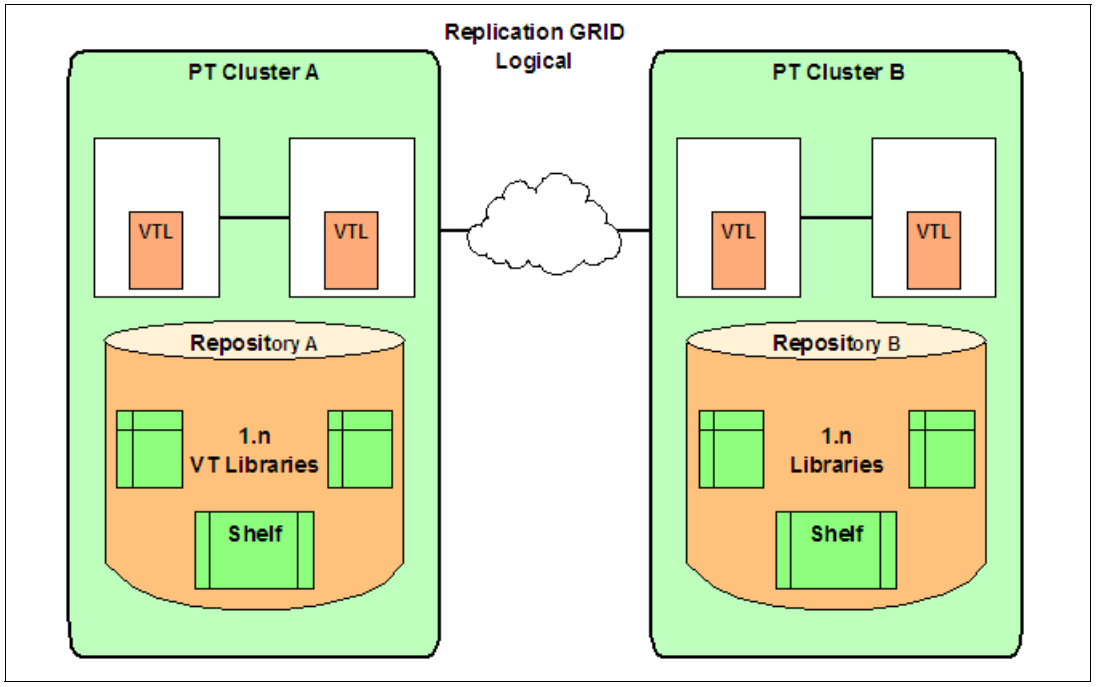


Figure 11-31 Replication grid topology example: Replication pair with two-node cluster systems

Replication minimizes its impact on backup and restore activities. Policies can be created so that you have the option of selecting which tapes they want to replicate. Up to 254 policies per repository can be defined.

11.16 Normal operation concepts

This section describes a normal ProtecTIER operation sequence when replication is used.

11.16.1 Replication

When the backup application is writing to a cartridge that is part of a replication policy, ProtecTIER checks when it needs to be replicated and what its priority is so that the cartridge can be put in the correct order in the replication queue. Cartridges are replicated from the local library at the primary site to the virtual shelf of the repository at the secondary (DR) site, or directly to a logical library, depending on how the visibility was configured in the replication policy.

By definition, cartridges that are created at the primary (local) site repository are set to be read/write enabled, so that the backup application at the primary site has full control of them and their content. Cartridges that were replicated to the secondary (remote) site are set to be in a read-only mode. By default, only one cartridge instance is in a library. The replica is located on the virtual shelf. If visibility switch is defined to a library, the replica cartridge is automatically moved from the shelf to the library at the target system after the cartridge is ejected from the source.

Important: By using ProtecTIER Manager, you can override the default location of any cartridge at any time. You also can manually move the replica from the virtual shelf to a library in the secondary site repository. However, the access to the cartridge remains read-only.

Cartridges are marked as synced after the data finishes replicating from the primary to the secondary site so that at the time of sync, the local cartridges and their remote replicas are identical. Up to 128 cartridges can be replicated simultaneously. Before replication starts running, the system ensures that only unique, new data is transferred over the TCP/IP link.

Important: If you delete a cartridge in the source repository, all the cartridge replicas also are deleted in the target repositories.

To achieve this transfer, each side holds sync data per each of its cartridges. This sync data is used by the destination (secondary, remote site) to determine which data (if any) should be replicated because only new and unique elements of data are sent over the network link to the remote site. The replication mechanism has the following types of data to transfer:

- Metadata: The data that describes the actual data and carries all the information about it.
- User data: The actual backed-up data.

A network failure that occurs while the replication operation is carried out leads to retries of up to seven consecutive days to replicate any specific cartridge that did not finish its replication because of the line failure.

11.16.2 Replication data transfer

When the replication action is started manually or based on a policy, the source (primary) ProtecTIER system carries out the following procedures:

- Initiates the sync-cartridge function between its own (source or primary site) repository and the destination (DR site) repository.
- Reads the unique replication data units upon requests from the remote ProtecTIER system based on what it is missing.
- Sends the unique data elements (by using TCP protocol) over the WAN to the remote (DR) site.

At the same time, the destination ProtecTIER system performs the following handshake actions:

1. Calculates the relevant cartridges' sync point where the replication should start.
2. Receives many data units concurrently as part of the replication action.
3. Verifies CRC for all replicated data before it becomes available as part of the cartridge.
4. After the CRC check proves successful, the system moves each of the verified data elements into the cartridge scope and makes it available for the user.

After all verified pieces are inserted into the cartridge, it becomes available as a complete cartridge. However, as a replica in the destination (DR) repository, it is set as read-only and cannot be used for backup purposes. This is an important factor in failover situations when the DR system might temporarily become the production site and can accept local backups. At that time, the user should create new tapes to accept this local backed-up data. These new local DR site tapes can be replicated to the primary site after it becomes available and ready for production again.

Important: A cartridge replica in the destination repository is always read-only and cannot be used to perform backups. They are for restore purposes only. If backup execution is required while in a DR situation, new scratch cartridges must be created at the remote site, which are later replicated back to the primary site during the failover process.

When the user moves operations back to the primary site during the failback process, the newly created cartridges from the DR site can be replicated to the primary site. Under these circumstances, the system grants read and write permissions to these replicated cartridges at the primary site, which becomes the owner of these tapes from that point on, just as though they were created there.

Important: The replication data transfer process requires that the replicated cartridge is at the remote (DR) site ProtecTIER VTL shelf. If the data transfer is being performed, these cartridges cannot be moved from the shelf. If the cartridge is manually moved from the shelf, it can cause replication errors if attempted to replicate.

11.16.3 Replication topologies in a VTL environment

The following types of topologies are supported at ProtecTIER version 3.2 when the VTL is used, shown in Figure 11-32 on page 408:

- Many-to-one replication topology
- Many-to-many replication topology

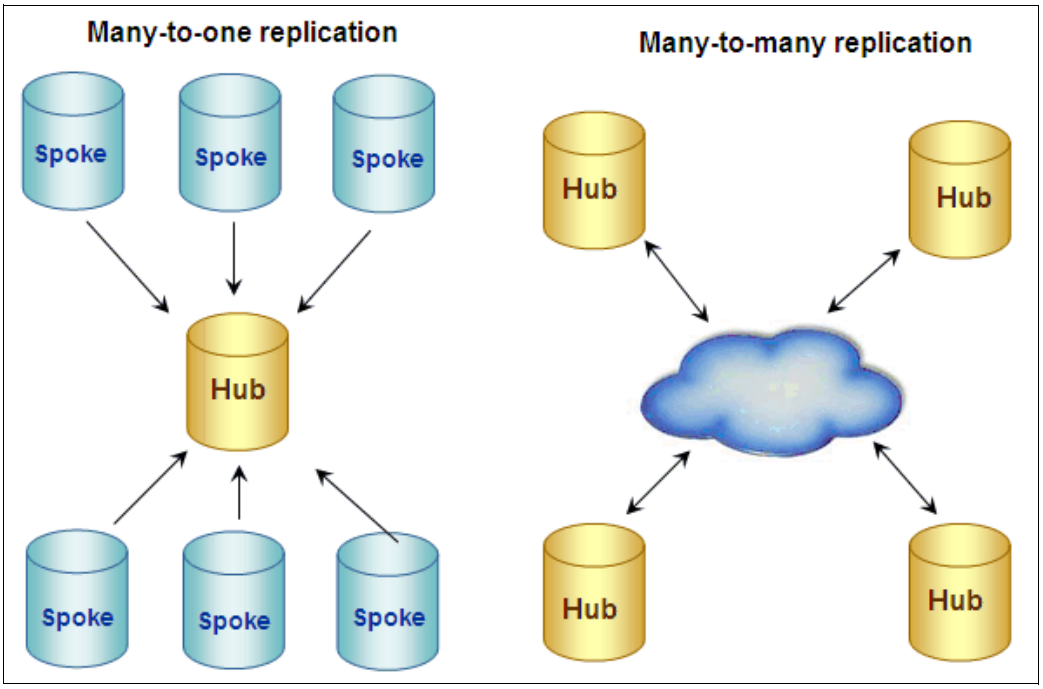


Figure 11-32 Many-to-one and many-to-many replication topologies

In a many-to-one replication topology, up to 12 source repositories (also known as *Spoke*) can perform local backups and replicate its data to a single destination repository (also known as *Hub*).

In a many-to-many replication topology, up to four repositories can perform local backups. They replicate to each other and receive and send data to another hub repository in the same replication group.

11.16.4 Visibility switch control

This is an automated process of the ProtecTIER replication feature, which transfers the visibility of a cartridge from its master to its replica, and vice versa.

Just like a real physical tape, a virtual cartridge can be in or visible only to the backup application in one location at a time. This is carried out by the ProtecTIER replication by using the VTL import/export slots. The system uses the export slots and eject operation as triggers to begin processing a tape move. The backup application can eject the cartridge into one of the export slots.

Upon ejecting a cartridge, it is first moved to the shelf on the local repository. On the remote repository, the cartridge is moved to the import/export slot of a library so that the backup application on the remote site can see it. When that cartridge replication action is completed, the cartridge appears at one of the import slots of the secondary (remote, DR) site and can be imported into a library.

Replication visibility is an attribute that is defined in a replication policy and can be set by the user. A specifically defined library in the remote repository must be selected for the visibility transfer to be carried out. After the cartridge is ejected at the primary (local) site, it moves to the local virtual shelf. Then, it is replicated as part of a policy to the remote site virtual shelf. After the replication is completed and verified, that replica moves to the respective library's import slot and can be imported into that library. At this point, that cartridge is visible only to the backup application at the remote site. A copy of the cartridge stays at the primary ProtecTIER system for fast recovery. However, it is hidden from the backup application and has read-only access.

The way to move the cartridge back and make it visible to the backup application at the primary site is to eject it from the remote library and import it back into the local one (the same library it came from). Because the system keeps a hidden copy at the primary site, this move back is instantaneous.

Important: You can run the cartridge visibility switch when the remote replica is fully synced. In case the replica is non-synced, replication is run for the cartridge automatically.

11.16.5 Single and multiple domain backup application environments

Any backup environment can be set up in many topologies. From ProtecTIER's replication standpoint, the following general setup methods for these environments are available:

- Single domain
- Multiple domains

The backup application catalog or DB has an entry for each cartridge used for backup, including the following entries:

- Date when backup was performed
- List of files associated with the backup
- Retention period
- Other backup application-specific information

The backup application supports one catalog DB per backup server instance. In many cases, the primary and remote (secondary, DR) sites have two separate backup servers, each with its own DB or catalog.

To efficiently read replicated cartridges at the remote site, the remote backup server needs access to the actual catalog or DB of the primary backup server or an exact copy of it. There are two basic backup environment topologies, as described in the following sections.

Single domain environment

In a single domain environment, the same backup application catalog (or database) is shared across the separate primary and secondary sites. In these environments, the catalog always is updated in real time on the locations of the cartridges (physical and virtual). For example, this type of environment is more commonly used with Symantec NetBackup (NBU) and does not work with most deployments of IBM Tivoli Storage Manager.

Multiple domain environment

A multiple domain approach is more widely used. This approach is where the backup application does not share the same catalog between the primary (local) and secondary (remote, DR) sites. This scenario is the most common with Tivoli Storage Manager environments. In this type of environment, each of the backup servers in the primary and secondary locations has its own backup catalog.

In a multiple domain environment, the backup server at the primary site manages the backup activity into the local ProtecTIER libraries.

An independent local backup server at the secondary remote location is used in case of a disaster (when the primary site is lost) to recover the replicated cartridges and potentially continue (temporarily) the production backup activity. In this type of environment, the following general steps are used to recover from a disaster:

- The secondary (DR) site backup server should be recovered first with the catalog or DB from the primary site.
- After it is up and running, this backup server should be used to restore data from replicated cartridges. It also might resume regular backup and restore production activity by using new (scratch) virtual cartridges.
- During the time frame that the production activity is conducted at the remote (DR) site, new backups register with the backup catalog or DB.
- After the primary site system is recovered and ready to become the production system again, the failback operation should be started. This replicates back all of the needed data (including newly created cartridges) to the primary location, which allows for synchronization between the two ProtecTIER repositories. It is important to synchronize the backup application catalog during this failback action to complete the recovery operation.

Remote cloning

Remote cloning is the process of using a secondary site to clone cartridges. ProtecTIER replication enables users to offload tape cloning to their secondary site. Many users replicate their data from the primary site to the secondary (DR) site, and then move it from the disk-based repository onto physical tape cartridges for long-term retention. One of the advantages of performing this practice at the secondary site is to take the burden of cloning to physical tape from the production environment to the remote location, which is where tapes most likely are kept after it is cloned. The remote cloning operation uses the cartridge replicas that are in the destination's ProtecTIER VTL shelf for cloning. The process imitates the commonly used physical process that involves the transportation of physical cartridges from the primary site to a remote site, either after being cloned or to clone them there for long-term archival purposes.

This feature is effective in single domain backup deployment, such as Symantec NetBackup (NBU) environment, because in these environments, the backup application servers at both sites share the same catalog and can be connected to the ProtecTIER systems concurrently. Within these environments, the replication visibility switch control feature should be used and the cartridges to be cloned should be moved from the primary repository to the secondary repository and then be cloned to physical tapes. In a single domain environment, the catalog is shared across the two sites and the backup application is fully aware of the locations and status of the cloned cartridges.

For more information, see 11.16.5, “Single and multiple domain backup application environments” on page 409.

Consideration for remote site tape cloning in a single domain environment

More than 90% of restore requests use the most recent backup tapes. The following best practice is for users who use the DR site physical tape cloning option in their operation:

1. Back up to the local, primary site ProtecTIER system.
2. Replicate to the secondary, remote site ProtecTIER while leaving the cartridge visibility at the primary site.
3. Five to seven days after replication has completed, change the visibility of the relevant cartridges from the primary, local site to the secondary, remote site.
4. Clone remote ProtecTIER tape copy to physical tape.
5. Change the visibility of these cartridges back to local ProtecTIER, after the tape cloning is completed.

This practice improves the probability of a virtual tape being available at the primary site when it is most likely to be used in support of a tactical restore at the primary location.

11.16.6 Adding replication to an existing production system

This section describes the options for upgrading an existing ProtecTIER TS7650 or TS7650G to a system that uses the replication feature to send data to a remote, secondary (DR) ProtecTIER system. The specific user scenario dictates the correct approach to upgrading the primary system and deploying the target system.

An important detail to remember during the planning process is that all of the nominal data that is associated with the initial cartridges physically must be replicated (there is no deduplication benefit on the bandwidth during these initial replication jobs). Also, the full contents of each cartridge that is associated with the replication policy must be replicated, even if only a fraction of the cartridge was used in the latest backup job.

For example, cartridge AB1234 is used during the first backup window following the deployment of replication, and 10 GB is written on it. However, it also holds 190 GB from previous backups. All 200 GB must be replicated during the first replication window for that cartridge. For this reason, we strongly suggest that a new user of ProtecTIER replication start fresh with new cartridges for all the jobs that are associated with the newly created replication policies, so no previously backed-up data must be physically replicated as new data is appended to an existing cartridge.

A deployment of a second ProtecTIER server at a secondary (DR) site suggests a significant implication on the planning cycle. The first replication jobs use much more bandwidth than required after deduplication takes effect. So when you are preparing for deployment, the field engineer must help the user's team plan and prepare the infrastructure and resources that are temporarily needed to support this. The plan must take into account the amount of physical data to be replicated, the amount of dedicated bandwidth, and the extra time that is needed for these first several replication runs. The user might need to allow the first replication job to complete before the next backup activity starts.

Before deploying the secondary (DR) system

The first step before the target IBM TS7600 is deployed with ProtecTIER is to confirm the bandwidth that is needed (or make a conservative estimate of it) with the user. Work with the user's network team to obtain IP addresses, port connections, and other network cabling, if needed. Verify that the network connections provide adequate speed. Use the Network Validation Utility that is available with the IBM TS7600 with the ProtecTIER system to verify the amount of bandwidth and the quality of the available user's network.

The second step is to determine the approach that the user takes to repository synchronizing between the local and the new secondary site systems. The key to a successful deployment here is a gradual replication load approach. The most efficient way to deploy replication with an existing operational IBM TS7600 with ProtecTIER system requires a load-throttle that introduces workload into the replication operation (policies) while staying under the available network bandwidth ceiling that is assigned between the two sites until steady state is reached.

This method is the only feasible and practical method to bring the secondary system to the point that it is fully synchronized with the primary system while using the available network bandwidth that was planned for the steady state after the deduplication factor takes effect. For example, if the first backup set to be replicated is 6 TB (full nominal) and the replication window is 10 hours, the amount of bandwidth that the user requires to allot will be 6 TB/10 hours = 600 GB/hour for the replication to be completed in the 10-hour window. Later on after the target and the primary systems are completely in sync, the deduplication factor takes effect. Assuming a 10% data change rate for that same job, the network bandwidth required is shown in the following example:

[(6000 GB * 10%) + (0.5% * 6000 GB)] / 10 hours = 63 GB/hour

This means that for the initial period of time, the user must allot enough network bandwidth to account for the full nominal size of the data to be replicated. Thus, creating replication policies with a gradual increase approach should be taken to stay within the available network bandwidth boundaries and within the replication window time frame.

11.17 Many-to-one replication with VTL

ProtecTIER many-to-one replication in VTL and OST configuration supports single node and clustered ProtecTIER configurations within all platforms, Appliance and Gateway, and the ProtecTIER Appliance Express; as shown in Figure 11-33. FSI configuration supports only stand-alone nodes.

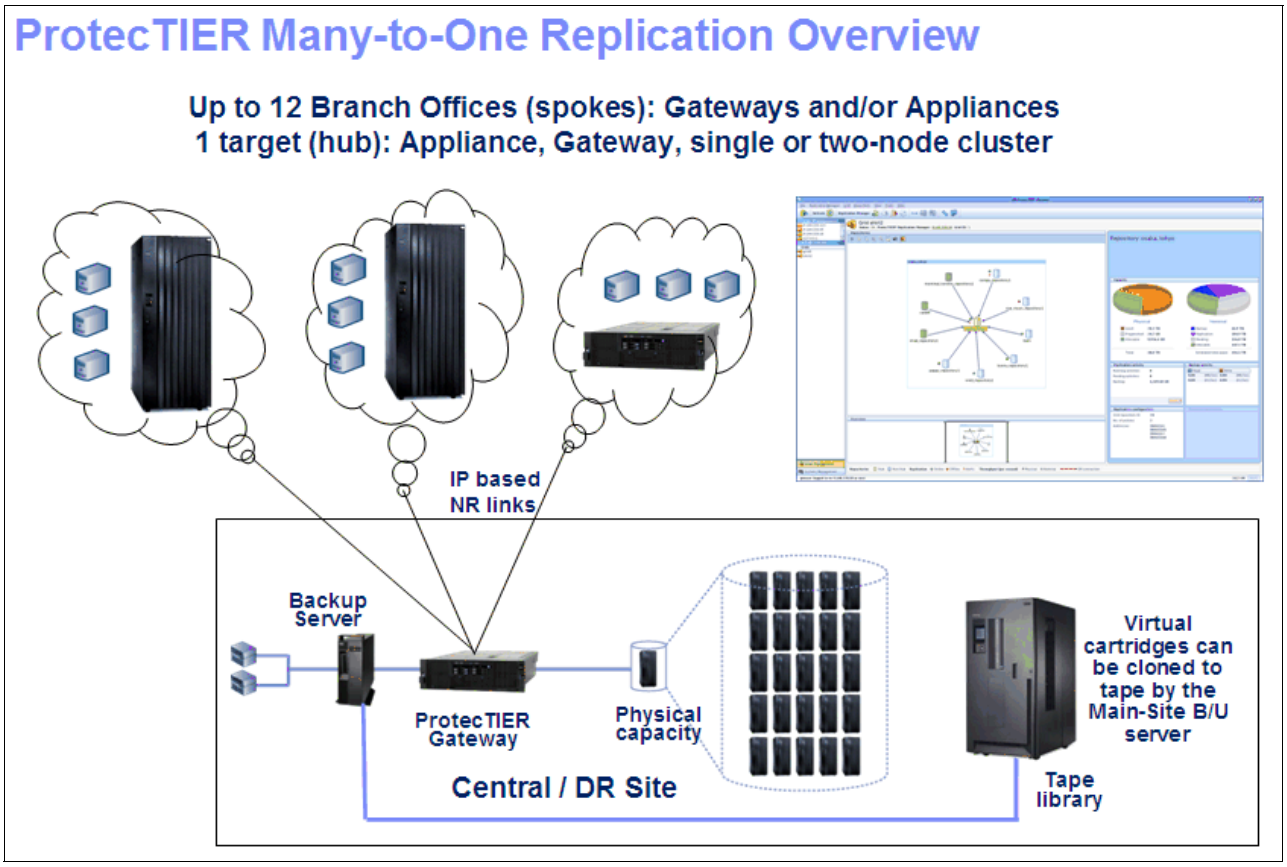


Figure 11-33 Many-to-one replication overview

In a many-to-one replication group, the repositories are divided into roles for replication. For replication roles, the sources are called spokes and the targets are called hubs. There can be different spokes and hubs defined within a grid. Every spoke and hub has its own repository. The user has different possibilities to set up his replication. It might be defined by which spoke replicates with which hub within a grid. The ProtecTIER Replication Manager must be installed and configured on a node within the grid.

Important: Only one spoke can be replicated with one hub. A hub can be the target of up to 12 spokes.

There can be different hubs within a single grid, as shown in Figure 11-34.

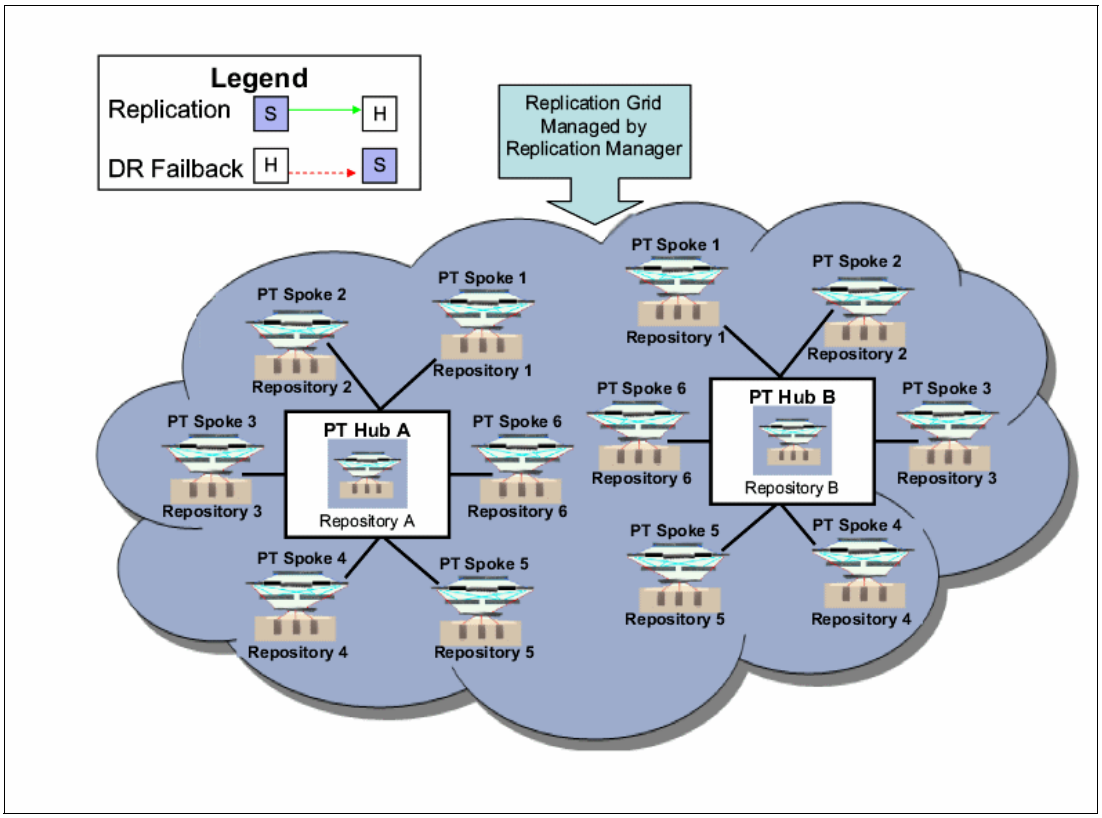


Figure 11-34 Replication Grid that includes two different hubs and connected spokes

11.17.1 Spoke

A spoke has the following characteristics:

- A spoke is the source repository that runs the user backups. The backups are replicated to a defined hub.
- A spoke cannot be the target of a replication.
- A spoke can replicate only to a single hub. There is no possibility to replicate with multiple hubs in a many-to-one replication group.
- In the ProtecTIER Manager, a spoke is identified as a blue repository.

11.17.2 Hub

A hub has the following characteristics:

- A hub is the target repository that can receive replications from up to 12 spokes.
- A hub also can be a target for local backups, but it cannot replicate them when choosing a many-to-one replication group.
- There can be eight active hubs defined per grid.
- There can be a maximum of 12 spokes defined for a single hub.
- In the ProtecTIER Manager, a spoke is identified as a golden repository.

The replication view of a many-to-one replication in ProtecTIER Manager is shown in Figure 11-35.

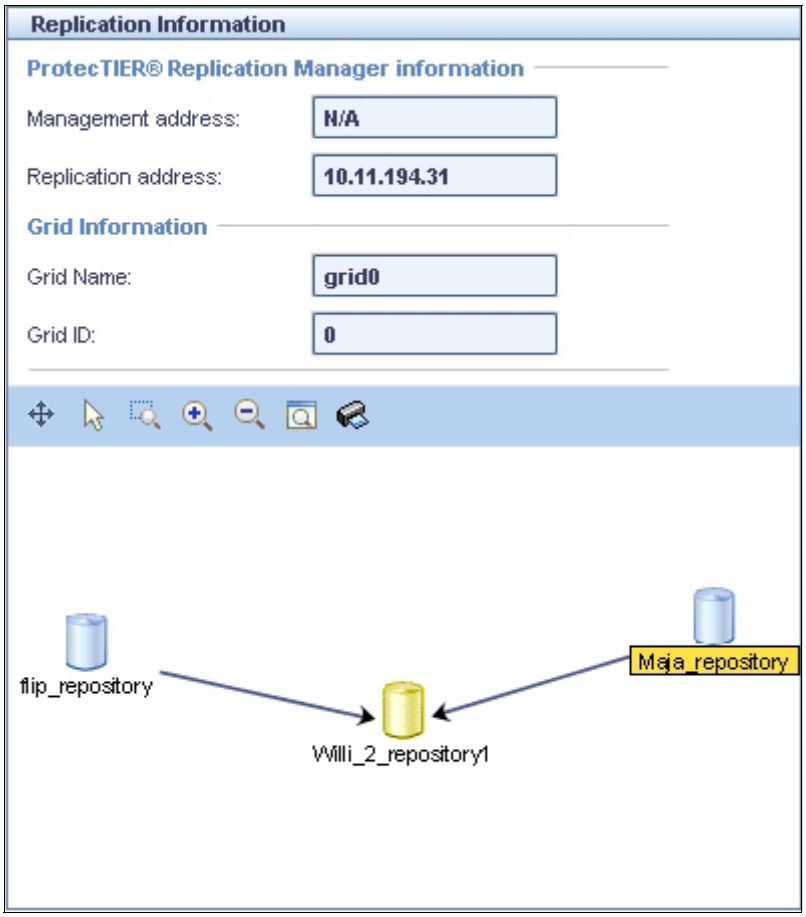


Figure 11-35 ProtecTIER Manager view of many-to-one replication

11.18 Many-to-many replication with VTL

ProtecTIER many-to-many replication in a VTL and OST configuration supports single node and clustered ProtecTIER configurations within all platforms, Appliance and Gateway, and the ProtecTIER Appliance Express, as shown in Figure 11-36. For FSI, only single node configurations are supported.

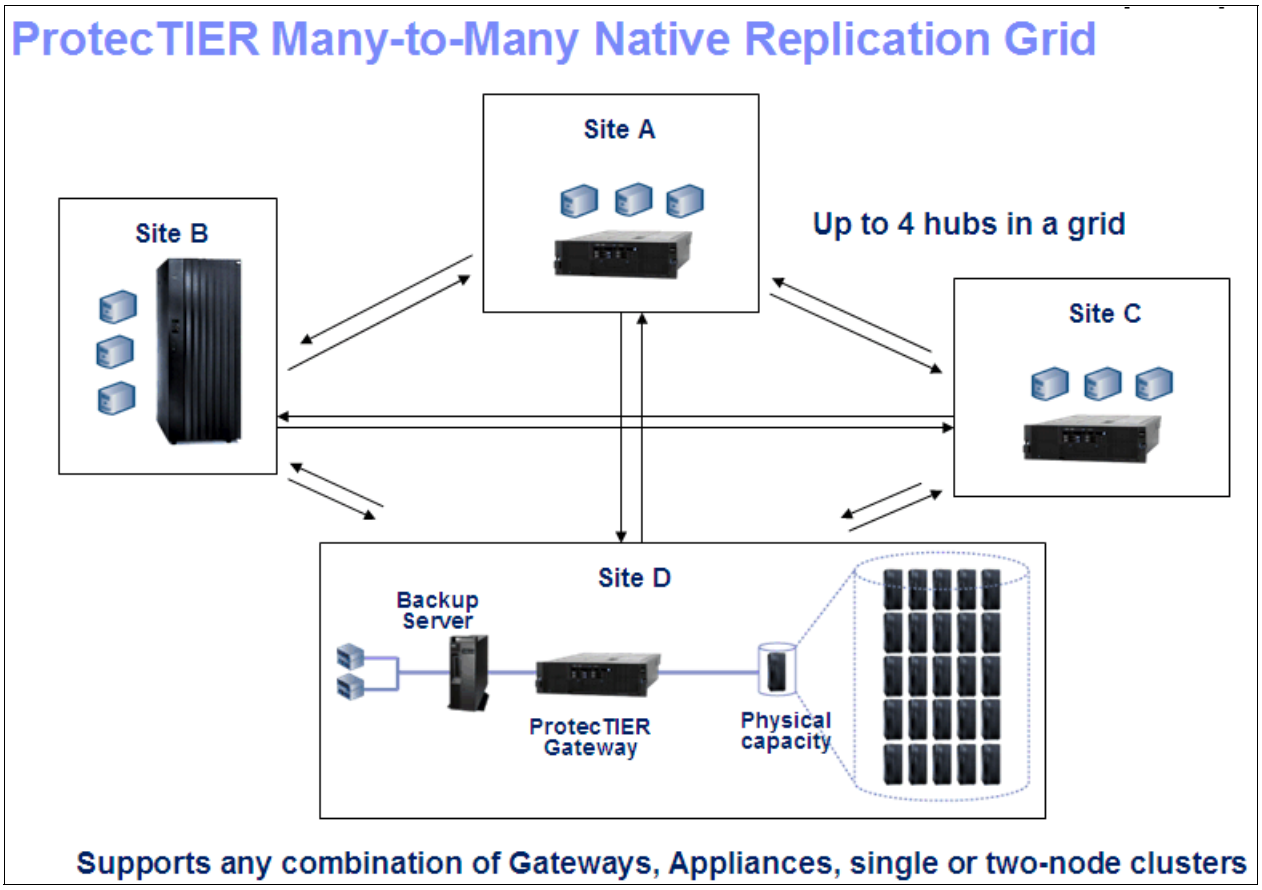


Figure 11-36 Many-to-many Replication overview

In a many-to-many VTL environment, replication groups are created where multiple repositories can replicate to each other. In a many-to-many replication group, all repositories are identified as hubs.

A many-to-many replication group can be defined with up to four repositories, where each repository assumes the responsibility of a hub repository and can receive local backups, replicate data to remote hub repositories, and receive replicated data from remote hub repositories.

The same cartridge can be replicated from its principal repository to up to three destination repositories. Different cartridges can be replicated between multiple hub repositories in a bidirectional manner.

The many-to-many VTL replication environment includes the following features:

- Up to four hub repositories replicating to each other is supported. A source repository can replicate a range of cartridges to up to three different destination repositories with different priorities.

- Each one of the hubs also is a backup target.
- There is bidirectional replication for many-to-many members (simultaneously).
- The repository is a member of only one group.
- Fail over, fail-back, and take-over is similar to M-to-1 (V2.4).
- Supported on all ProtecTIER hardware options.
- There are separate schedules for incoming and outgoing replication.
- Up to 256 policies can be defined per repository and up to 1023 ranges of cartridges can be defined per replication policy.
- Each hub is capable of performing local backup and recovery operations and replication activity.
- Visibility switching can be enabled on one of the destination repositories.

Important: A repository is a member of a many-to-many group or a many-to-one group. Both groups can exist in parallel in the same grid, but a repository is a member of only one group.

From a many-to-one topology, source repositories are not supported in a four-way many-to-many replication grid.

In Figure 11-37, you can see the replication view of a many-to-many replication in ProtecTIER Manager.

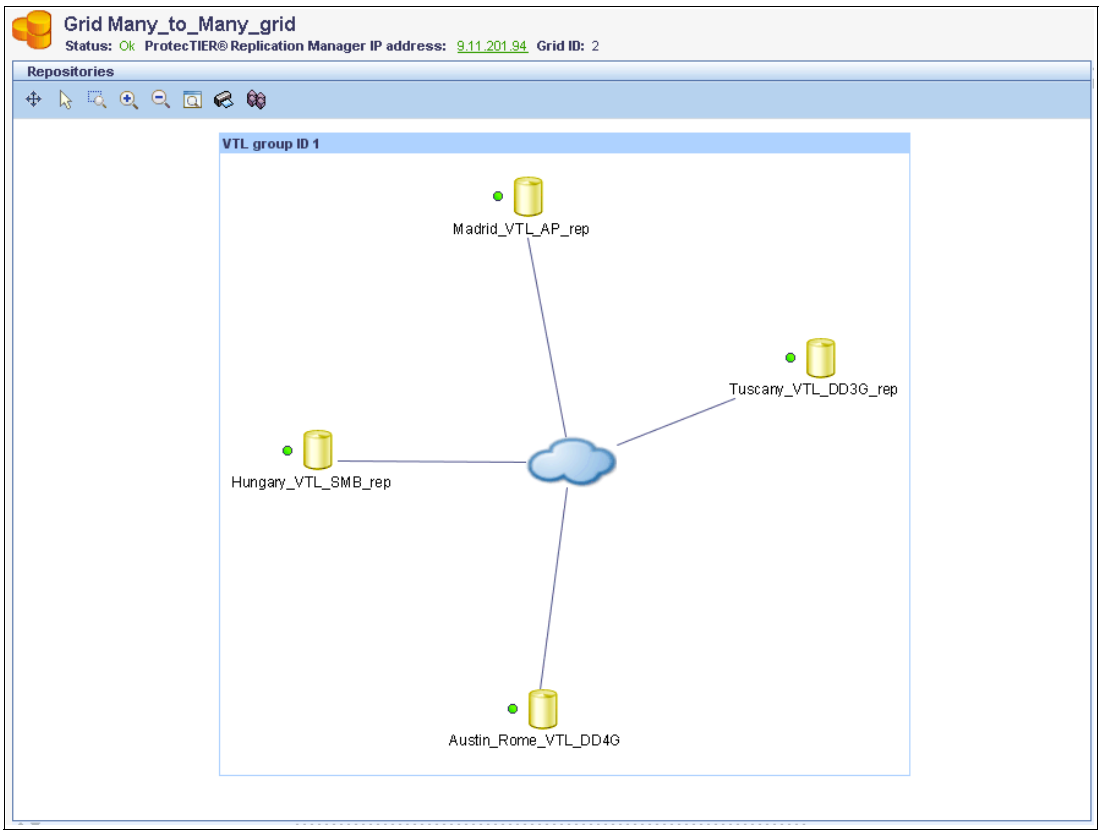


Figure 11-37 ProtecTIER Manager view of many-to-many replication

11.19 ProtecTIER Replication with OST

ProtecTIER Release V2.5 adds the OST, which is a Symantec NetBackup application programming interface (API) that supports direct communications between Symantec NetBackup and OST-enabled ProtecTIER systems.

With OST, ProtecTIER can be integrated with NetBackup to provide the means for backup-to-disk without the use of a VTL emulation. By using a plug-in that is installed on an OST-enabled media server, ProtecTIER can implement a communication protocol that supports data transfer and control between the backup server and the ProtecTIER server. Therefore, to support the plug-in, ProtecTIER implements a storage server emulation. If you want to configure the ProtecTIER server for OST, make sure that a repository was created with OST as backup interface. For OST use, the repository is defined in logical storage units (LSUs). The LSU also is defined in the OST API and is a container of storage. Up to 256 LSUs can be defined per ProtecTIER server and are identified by a name string that is unique within the storage server.

11.19.1 Replication with OST

In an OST environment, replication policies and activities are managed by Symantec NetBackup (NBU). ProtecTIER Replication Manager is used to manage the replication grid, create application groups, and define the replication connections within the replication grid. Each repository (or grid member) can replicate to each other and replication is bidirectional. A maximum of 12 repositories (members) can replicate to each other at any time, with up to 256 repositories existing in the entire grid.

11.19.2 ProtecTIER Replication Manager tasks in OST

ProtecTIER Replication Manager is responsible for the following tasks in OST:

- Managing the repositories in the replication grid that can be replicated to
- Maintaining the IP addresses of all repositories
- Updating of repositories that are leaving and joining the grid
- High-level monitoring and statistics of traffic in the replication grids

In Figure 11-38, you can see the ProtecTIER Manager for an OST-enabled ProtecTIER system in an OST hub mesh replication group.

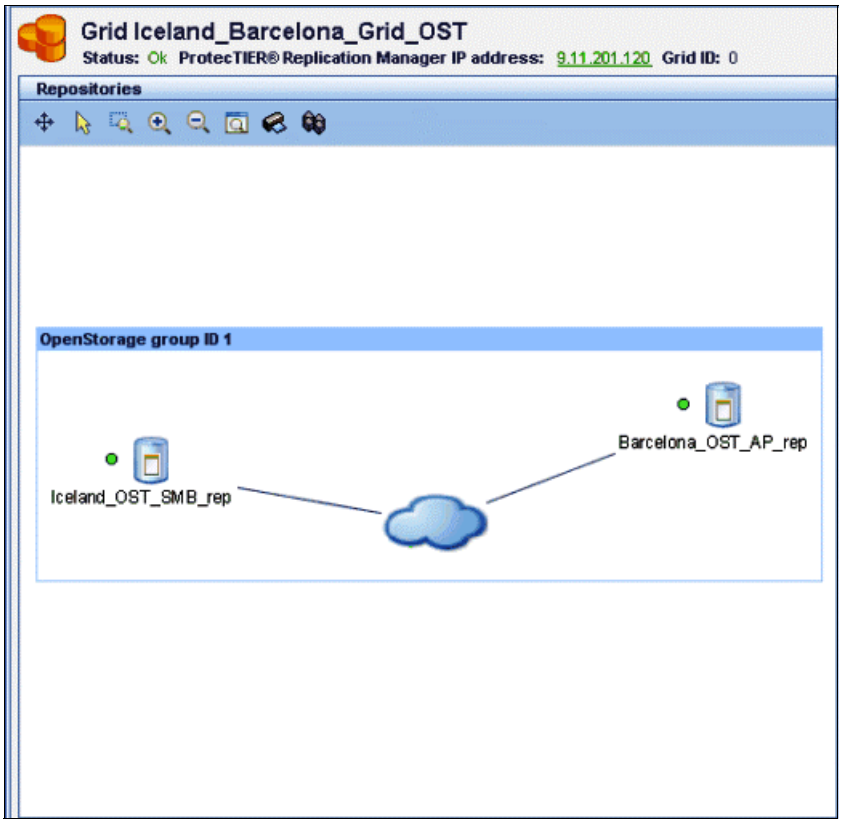


Figure 11-38 ProtecTIER Replication Manager with OST replication group

11.20 ProtecTIER Replication with FSI

ProtecTIER Release V3.2 adds the FSI functionality to the TS7600 family of products. By using FSI, ProtecTIER emulates Windows file system behavior and presents a virtualized hierarchy of file systems, directories, and files to Windows CIFS clients. Clients can perform all Windows file system operations on the emulated file system content. Working with file systems by using ProtecTIER for FSI involves tasks such as creating, modifying, and deleting file systems. From ProtecTIER version V3.3, the server also supports NFS exports on the machine with CIFS shares.

11.20.1 Replication with FSI

FSI supports an eight-way many-to-many replication topology group. Each repository assumes the responsibility of a destination or source repository and can receive local FSI backups, which replicate data to remote repositories, and receive replicated data from remote repositories. The same data can be replicated from its principal source to up to three destination repositories. Different data can be replicated between multiple repositories in a bidirectional manner.

ProtecTIER servers are organized in replication groups where they can send data to each other. After this configuration is set up, you can create replication policies as needed. When FSI replication policies are configured, objects can be selected on the source repository to replicate at the directory level. All subdirectories and files that are contained in the selected directory are replicated to a specific directory on the destination repository, which, in turn, can be used to recover and restore data to the source file system. The specific directory on the destination repository within ProtecTIER is known as a replication destination directory (RDD). The replication destination directory must be an empty directory under the root directory of the file system. Only read-only shares can be created on a replication destination directory.

A replication destination directory is required for each replication policy. A policy is a rule for replicating directories from one repository to another. On the source, up to 64 directories can be selected per policy and up to 256 policies per source repository are supported. A replication policy supports a source repository that replicates data to up to three different destination repositories. When multiple destination repositories are replicated to via a replication policy, each destination repository must have a specific replication destination directory defined. A replication destination directory cannot be replicated.

Important: All tasks that are associated with the management of replication policies are online operations and are performed without taking repositories offline.

You can clone an FSI directory for disaster recovery purposes so you can see what was replicated on an RDD. By cloning in FSI, you can perform disaster recovery tests at a replication destination repository while replicating the original data from the source repository to the destination repository to continue. All existing data in the repository remains accessible during cloning.

FSI replication traffic can be suspended, resumed, and blocked. Suspending replication activity temporarily pauses data replication between a source and a destination. Whereas blocking incoming replication activities is not a temporary state, and must be reactivated when needed.

11.21 IBM TS3000 System Console

An IBM TS3000 System Console (TSSC) (formerly the TotalStorage Service Console) is required for installation, service, and maintenance of the TS7600 family. You can use an existing TSSC if it is within line of sight of the TS7600 family. The TSSC provides a single point of service for gathering logs and remote support. An analog phone line is required for the auto-call feature.

Important: If you need a TSSC, you can order it with the TS7600 family and they are shipped together.

11.22 Operating system

The required operating system that is used with the ProtecTIER is Red Hat Enterprise Linux 5.6 Advanced Platform. IBM ProtecTIER Enterprise Edition V3.3 software and Red Hat Enterprise Linux 5.6 Advanced Platform (RHELAP) x86_64 are loaded on the IBM TS7600 family with the ProtecTIER initial order.

For more information about the operating system and how to reload a system, see the TS7650 section of the IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/STLPPL/com.ibm.storage.ts7650_3-3.cust.doc/welcome/ts7650_c_kc.html?cp=STLPPL%2F1

12

Library management

This chapter provides information about the tools and technologies that can be used to perform initial and ongoing library configuration and maintenance and to monitor the technical health of the library. It includes an introduction to Tape Systems Library Manager (TSLM), which can manage the TS3500 shuttle complex and other large TS3500 installations. In addition, this chapter highlights management features that are unique to specific tape library models.

Note: For details on the IBM TS4500 library management, see *IBM Tivoli Storage Productivity Center Beyond the Basics*, SG24-8236.

This chapter includes the following topics:

- Overview of library management
- Management tools and technologies
- Library-specific management capabilities
- Preferred practices

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12.1 Overview of library management

For the purposes of this chapter, the definition of *library management* includes the tasks that are associated with initially configuring a tape library and then performing the ongoing tasks necessary to maintain technical health. This chapter does not include information about operational tasks, such as loading and unloading cartridges. Therefore, this chapter provides information about the tools that are available (not about the management tasks in detail) to assist in performing the tasks that are presented in this chapter.

The following tasks are general and do not necessarily apply to all libraries:

- Configuration customization:
  - Defining logical libraries
  - Defining a network address for the library Ethernet interface
  - Bringing drives and logical libraries online and offline
  - Defining how many characters to use in the volume serial (VOLSER) number
  - Defining user IDs to use to access the web interface or operator panel
  - Enabling automatic tape drive cleaning
- Configuration viewing, which includes displaying the following information regarding the library configuration:
  - Drive information, such as serial numbers, worldwide names (WWNs), and which cartridges are loaded
  - Cartridge inventory
  - I/O slot occupancy
  - Logical library configuration
- Displaying error messages, which refers to seeing which error messages were recorded by library components and tape drives
- Alerting error messages, which refers to sending error messages by email or Simple Network Management Protocol (SNMP) to another location for attention
- Updating firmware, which refers to keeping library and drive firmware up-to-date

12.2 Management tools and technologies

This section provides information about the following tools and technologies that can be used to assist with library management:

- Operator panel
- Web user interface (web UI)
- Command-line interface (CLI)
- Tape System Library Manager
- TapeAlert
- Tape System Reporter
- SNMP
- SMI-S
- Tivoli Storage Productivity Center
- IBM TotalStorage Tape Diagnostic Tool
- IBM Ultrium Device Driver

12.2.1 Operator panel

The operator panel is the LCD window on the front of each library. It is operated by pressing buttons or by using the touch-sensitive screen. Most of the tape management tasks are performed directly from the operator panel. The menu items that are available are different on the models of tape libraries. To confirm exactly which menu options a particular library shows, see the relevant setup and operator guide.

The operator panel on most IBM tape libraries includes the following typical features:

- Library configuration:
  - Setting the network address
  - Bringing drives online and offline
  - Changing the mode of the library from random to sequential (TS2900, TS3100, and TS3200)
  - Configuring logical libraries (TS3100, TS3200, TS3310, and TS3500)
  - Configuring the library to send an email message with the error conditions (TS2900, TS3100, TS3200, and TS3310)
  - Configuring the library to send error conditions as SNMP traps (TS2900, TS3100, TS3200, TS3310, and TS3500)
- Viewing configuration details about the following information:
  - Firmware levels for the library and the drives
  - Library inventory
  - Drive serial numbers
  - The number of empty slots and occupied slots
  - Cartridges in the I/O slots
- Diagnostics:
  - Displaying error logs
  - Running diagnostic routines to test the library and tape drives
- Control:
  - Unlocking the I/O station
  - Moving cartridges
  - Performing an inventory

Most management tasks can be performed through the operator panel. However, the inherent drawback is that someone must be physically present to activate the panel and view the output. (Directing a colleague over the phone to operate the panel and read back what that person sees generally yields unsatisfactory results.) With tape libraries often located remotely from those people who manage them, the operator panel is often inadequate in meeting the needs of library managers. However, it is the main interface that is used by IBM support service representatives (SSRs).

Looking at the physical drawbacks of onsite access, many new tools and technologies were introduced over time to make remote access easier and convenient. The remainder of this chapter describes the remote management capabilities of the IBM tape products.

12.2.2 Web user interface

The remote management of tape libraries through a web UI is a standard feature of all currently marketed IBM tape libraries. The menu options and the style of the web UI differ between the library models. However, they offer broadly similar functionality. Use of the web UI is implemented by configuring an IP address through the operator panel. In addition, user IDs and passwords can be defined with different access levels.

Important: Each tape library ships with a default administrative user ID (`admin`) and password (`secure`) for accessing the web UI. This default should be changed immediately after the network address is defined.

Restricting access to the web UI is optional on earlier tape libraries. Restricting access to the web UI always should be enabled.

To view the web UI sign-on in a window, the web address should be entered in the browser. Figure 12-1 shows the main window after sign-on. The options in this window provide essentially the same functionality as the options that are provided by the operator panel.

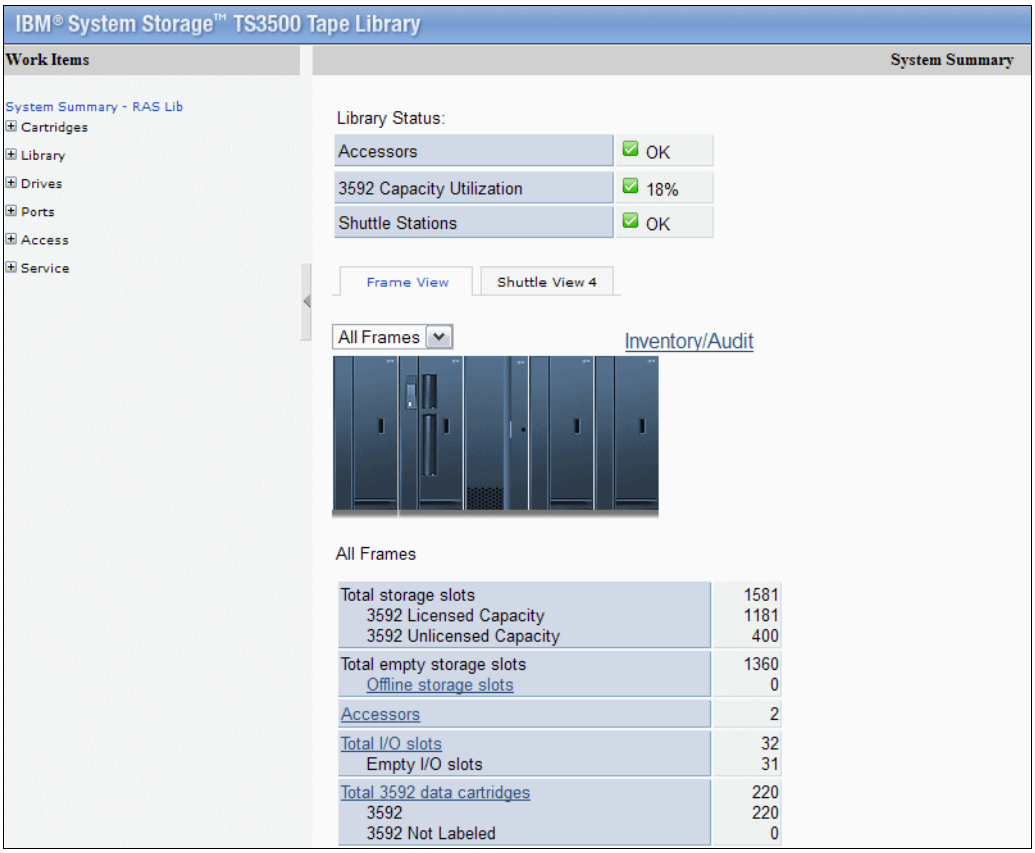


Figure 12-1 The web UI sign-on window for the TS3500 tape library

Although the web UI and operator panel functionality are similar, certain library models, such as the following examples, can have specific functionality that is available only through the web UI:

- The TS2900 tape autoloader:
  - User access configuration
  - Event notification configuration
  - Key path diagnostics
  - Download library logs
  - Encryption
  - Reset library/drives
- TS3100 and TS3200 tape libraries:
  - Event notification configuration
  - Error log configuration
  - Library restart
  - Encryption
  - Library firmware upgrade (only possible through the web UI)
- TS3310 tape library:
  - Library firmware upgrade (only possible through the web UI)
  - Advanced reporting
- The TS3500 tape library:
  - Advanced Library Management System (ALMS) configuration
  - Download of detailed logs regarding the mount history, drive statistics, Fibre Channel port statistics (available with library firmware 5500), and library statistics (available with library firmware 6*xxx*)

The documentation that is shipped with each library should be checked to confirm the functionality available through the web UI for specific library models.

The web UI is a comprehensive tool. Every library must be network-connected to take advantage of the facilities available. Some of the functionality that was outlined is available only through the web UI, which makes this tool indispensable.

12.2.3 Command-line interface

The IBM tape library command-line Interface (CLI) programs can be used to access the TS3500 and TS3310 tape libraries from a CLI. The CLI is available in addition to the TS3500 tape library and TS3310 tape library web UIs and is oriented to the open system platforms.

TS3500 tape library CLI

Cartridge movement can be started by using the TS3500 tape library CLI, which generally is performed based on the current cartridge location:

- Moving to storage
- Moving to drive
- Moving to I/O

For more information about downloading the CLI programs and about the CLI commands and their syntax, see the downloads table at the following website:

https://www.ibm.com/support/docview.wss?uid=ssg1S4000854

TS3310 tape library CLI

The following cartridge movements can be performed by using the TS3310 tape library CLI, which is generally performed based on the current cartridge location:

- Moving to storage
- Moving to I/O

For more information about downloading the CLI programs and about the CLI commands and their syntax, see the downloads table at the following website:

https://www.ibm.com/support/docview.wss?uid=ssg1S4000981

12.2.4 Tape System Library Manager

Tape System Library Manager (TSLM) software provides consolidation and simplification benefits in an open systems IBM TS3500 tape library environment.

TSLM provides a resource management layer between applications such as Tivoli Storage Manager and the tape library hardware. Essentially, TSLM decouples tape resources from applications, which simplifies the aggregation and the sharing of tape resources.

TSLM can combine the capacity of multiple TS3500 libraries into a single reservoir of tape storage that can be managed from a single point, which allows more effective management, monitoring, and reporting of the use of tape storage resources for new and existing TS3500 systems. It also supports the TS3500 shuttle complex.

TSLM includes the following functions:

- Enables clients with large tape environments that span multiple TS3500 tape libraries to manage them as a single system consists of one or more pools of drives and cartridges.
- Enables IBM Tivoli Storage Manager support for the TS3500 shuttle complex.
- Simplifies the creation and management of Tivoli Storage Manager tape drive paths to the TS3500 in the storage area network.
- Consolidates mainframe-class media management services.
- Provides investment protection of tape drives and cartridges for customers that use applications that are designed for the IBM 3494 tape library.

TSLM provides the following features:

- Centralized repository, access control, and administration
- Management beyond physical library boundaries:
  - Access multiple TS3500 libraries as a single TS3500 library image
  - TS3500 libraries can be separate or connected in a shuttle complex
- Dynamic sharing of resources across heterogeneous application boundaries
- Security features to permit or prevent application access to tapes:
  - Create common scratch pool and private pools for every application
  - Ensure secure use and visibility
- Policy-based drive and cartridge allocation
- Policy-based media-lifecycle management

- Tivoli Storage Manager enhancements:
  - Simplify path management in Tivoli Storage Manager
  - Simplify device sharing
- Emulation of legacy 3494 library operation with TS3500 for applications that are designed specifically for 3494 libraries

For more information about TSLM, see 10.1.7, “Tape System Library Manager” on page 319.

12.2.5 TapeAlert

All IBM Ultrium tape libraries are compatible with TapeAlert technology. This technology provides error and diagnostic information about the drives and the library to the server to which the drives are connected. TapeAlert is an industry standard that defines status conditions and problems that are experienced by devices, such as tape drives, autoloaders, and libraries. The standard enables a TapeAlert-aware application, such as IBM Tivoli Storage Manager, to read TapeAlert messages (called *flags*) from a tape drive through the SCSI bus.

If IBM Tivoli Storage Manager events are monitored by using the IBM Tivoli Enterprise Console®, the follow-on product IBM Tivoli Netcool®/OMNIbus, or SNMP, IBM Ultrium tape libraries can be monitored indirectly by enabling tape alert messaging within Tivoli Storage Manager.

TapeAlert is a technology that is inherent in IBM Ultrium and Enterprise tape drives to permit sending tape and library alerts to servers that are connected to the tape library. It is useful if servers and applications, such as Tivoli Storage Manager, already are monitored because the tape libraries and drives also are monitored by default.

12.2.6 Tape System Reporter

With the IBM Tape System Reporter application, customer operators and storage administrators of the TS3500 tape library can monitor and report on storage devices in an enterprise environment.

The IBM Tape System Reporter application is a Windows based graphical user interface (GUI) software application that can be used to monitor and gather data for multiple libraries. A monitor report can be generated, followed by a General SQL Query or custom report on the use and performance of tape cartridges, tape drives, and the tape library that is monitored. With IBM Tape System Reporter, application operators and storage administrators of the TS3500 tape library can monitor and report on storage devices from any location in an enterprise environment. This application communicates directly with the library via an Ethernet connection to collect and store pertinent data in a database so that performance trends can be generated and viewed (as shown in Figure 12-2 on page 430). The IBM Tape System Reporter application is bundled with the TS3500 tape library ALMS.

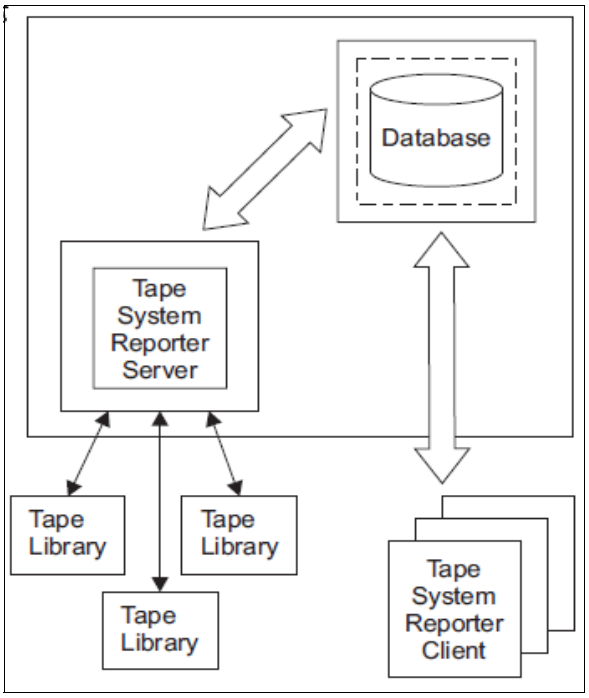


Figure 12-2 Data flow of the Tape System Reporter application

The Tape System Reporter provides a report of data that is collected from the 3592 tape drives (models J1A and later) and the Linear Tape-Open (LTO) Ultrium tape drives (models Ultrium 2 and later). More customer-centric Statistical Analysis Reporting System (ccSARS) data is available for the TS1120 (3592 E05), LTO Ultrium 4, and later tape drives and can be collected by the Tape System Reporter for further analysis in a Rollup report.

To use the IBM Tape System Reporter application, connectivity must be established to any tape libraries that it is monitoring. The application can be installed by the customer or by IBM Lab Services.

Important: Data is not collected for the LTO Ultrium 1 tape drive.

Tape System Reporter reports mount history for all TS3500 tape library models and their drives (except for LTO-1 drives). It also provides information about the library performance for models (L23 and L53) with the enhanced node cards.

Tip: Install the IBM Tape System Reporter application on a dedicated server machine that is separate from the client machine or machines. This installation is effective when balancing workload is a consideration.

Rollup report

With the Rollup report feature, you can generate a rollup report in a graph or table, or export data in the `.csv` file format for one of the following pieces of information:

- Host Writes - Mount History (in MB), which is available with TS3500 tape library microcode version 8140 and later
- Host Reads - Mount History (in MB), which is available with TS3500 tape library microcode version 8140 and later

- Drive Residency - Mount History (in minutes), which is available with TS3500 tape library microcode version 8140 and later
- Write Retries Media - Mount History (count)
- Write Perms Media - Mount History (count)
- Read Retries Media - Mount History (count)
- Read Perms Media - Mount History (count)
- Mount Total - Library Performance (count)
- Ejects Total - Library Performance (count)
- Total Inputs - Library Performance (count)

The ccSARS data is available for the TS1120 (3592 E05), TS1130 (3592 E06), TS1130 (3592 EU6), TS1140 (3592 E07), TS1150 (3592 E08), LTO Ultrium 4, Ultrium 5, and Ultrium 6 tape drives.

The ccSARS report can include the following values:

- Mount Rating Drive
- Mount Rating Media
- Mount Rating Ports
- Mount Rating Port0
- Mount Rating Port1
- Mount Write Perf Util
- Mount Write ERPs Impct
- Mount Write Burst Util
- Mount Write Buffer Util
- Mount Read Perf Util
- Mount Read ERPs Impct
- Mount Read Burst Util
- Mount Read Buffer Util
- Mount Capacity Total Util
- Mount Capacity Writes Util

Efficiency

With the Tape System Reporter feature, reports can be generated to show how much a drive, VOLSER number, or a logical library writes per mount per minute. Efficiency is available on Host_Read and Host_Write for both Mount History and Library Performance. The efficiency fields are Per Mount and Per Second (while mounted).

Tip: If you have the latest code level, you can generate reports for Host Writes, Host Reads, Drive Residency, and Efficiency.

For more information about the Tape System Reporter, see this website:

`http://www.ibm.com/support/docview.wss?rs=1159&uid=ssg1S4000680`

Reports

The example shown in this section shows how the IBM Tape System Reporter application can be used practically. With the IBM Tape System Reporter application, various reports can be generated to help analyze the performance of tape cartridges and tape drives.

Example of use

A customer wants to see how drives in the `sltlib1` library are performing. The `sltlib1` library has drives on Frame 2 and Frame 3. A custom report is selected to query Frame 2 and drives 5 to 12 and Frame 3 drives 1 and 2. The bar graph query is submitted, and the report that is shown in Figure 12-3 is returned.

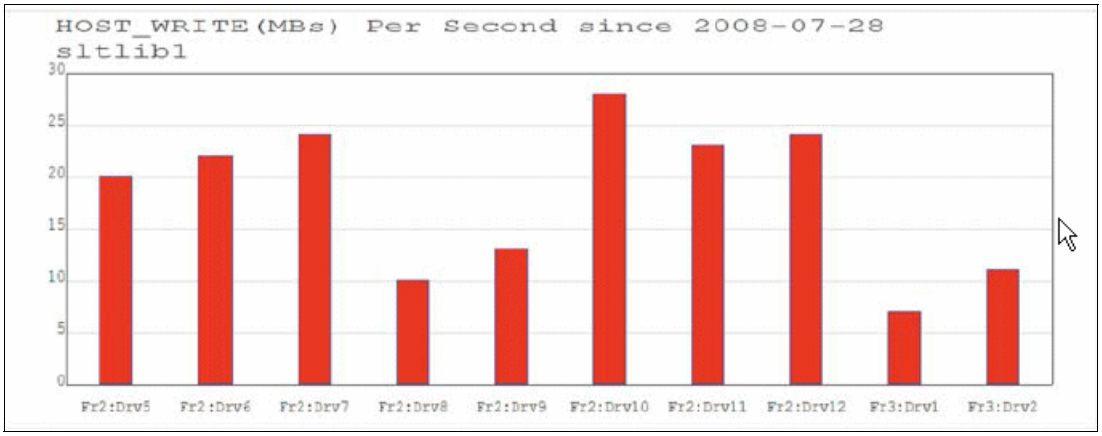


Figure 12-3 Performance graph

The report shows that Drives 8 and 9 on Frame 2 and Drives 1 and 2 on Frame 3 are lower performing when compared with the other drives. They are slower in Data Write transfer MBps. The graphical view does not indicate why these drives are performing slower. However, it indicates an area of concern. Deeper investigation can be performed to see if the slow transfer rates were caused by a bad cartridge, slow adapter, the drive, or another issue.

For more information, see *IBM System Storage TS3500 Tape Library with ALMS Tape System Reporter User's Guide*, GA32-0589.

12.2.7 SNMP

SNMP forms part of the Internet Protocol suite as defined by the Internet Engineering Task Force (IETF). Originally developed in 1988, the protocol can support monitoring of network-attached devices for any conditions that warrant administrative attention. The protocol was developed from its original inception as Version 1 to Version 2 and Version 3.

Managed devices (*agents*) can send SNMP traps or notifications (alerts about a change in state) to an SNMP Manager, such as IBM Tivoli NetView, from which multiple network devices can be monitored and managed. The details of these conditions that can cause alerts are described in a Management Information Base (MIB). An MIB is a formal description of a set of network objects that can be managed by using SNMP. This file must be loaded into the SNMP Manager so that the notifications that are received can be correctly interpreted.

The TS2900 tape autoloader, TS3100, TS3200, TS3310, and TS3500 tape libraries support SNMP. For more information about downloading the MIB file for these tape products (except for the TS3310 tape library), see this website:

`http://www.ibm.com/support/fixcentral/`

12.2.8 SMI-S

As storage technologies become increasingly affordable, the demand for storage hardware also increased. As a consequence, the workload that is associated with managing this expanding infrastructure also is increasing. The task of staying in control of tape libraries, SAN switches, and disk arrays from a variety of vendors, each with their own unique management tools, becomes a greater challenge.

Against this background, the Storage Networking Industry Association (SNIA), which is a vendor neutral organization, defines standards-based management for storage devices. The goal of the use of a single tool to permit management of storage devices from various vendors is possible only if those storage devices conform to an agreed to management interface. The SNIA defined an interface for just this purpose, the Storage Management Interface Specification. If a device conforms to SMI-S, Resource Management Applications that use the SMI-S, such as the IBM Tivoli Storage Productivity Center, can manage aspects of those storage devices that are defined in that version of the SMI-S.

Products that conform to SMI-S can be submitted to the SNIA to demonstrate that they pass conformance tests that are defined by the Storage Working Groups in the SNIA. For a list of product providers that can demonstrate conformance, see this website:

http://www.snia.org/ctp/conformingproviders

IBM tape libraries and SMI-S

The SMI-S Agent is the implementation of the Common Information Model (CIM) of IBM. The CIM is an interface standard in the enterprise's storage network environment that enables interoperability for hardware and software products that might come from different manufacturers. The CIM provides common protocols and data models that storage product manufacturers can use to ensure ease of use and manageability of the storage network environment.

IBM achieved official conformance for the management of the TS3310 and TS3500 tape libraries, which was accomplished by implementing the SMI-S Agent for Tape on a Linux system. The Agent acts as an interface between the Resource Management Application, the IBM Tivoli Storage Productivity Center, and one or more TS3310 and TS3500 tape libraries. An embedded SMI-S agent is not provided with, or supported by, the TS3500 tape library.

12.2.9 IBM Tivoli Storage Productivity Center

Tivoli Storage Productivity Center is a suite of storage infrastructure management software. It can centralize, automate, and simplify the management of complex and heterogeneous storage environments. It can improve storage capacity use and administration efficiency. Tivoli Storage Productivity Center brings together in a single interface the management of storage devices, fabric, and data. Tivoli Storage Productivity Center supports the TS3500 tape library, TS3310 tape library, and any other SMI-S compliant tape subsystems.

Tivoli Storage Productivity Center provides the following capabilities:

- Alerting

  Conditions such as SNMP traps that are issued from managed devices can be logged and optionally cause another action to be started; for example, sending the event to a Tivoli Enterprise Console or to the follow-on product Tivoli Netcool/OMNIbus.

- Configuration display

  The current configuration and use of storage devices can be viewed.

- Device discovery

  Tape libraries, disk, and fabric devices can be automatically discovered to facilitate Tivoli Storage Productivity Center configuration.

- Management

  Devices can be manually configured from within the Tivoli Storage Productivity Center, such as the IBM SAN Volume Controller.

- Monitoring

  Thresholds can be set that trigger actions. For example, if the system use of a file expands beyond 90%, a script can be run to increase the size.

- Topology viewer

  Displays how storage elements are connected; for example, which tape drives are connected to which ports on a SAN switch.

For more information about Tivoli Storage Productivity Center, see *IBM TotalStorage Productivity Center V3.1: The Next Generation*, SG24-7194, and *Tivoli Storage Productivity CenterV4.2 Release Guide,* SG24-7894.

12.2.10 IBM TotalStorage Tape Diagnostics Tool

The command-line tools, TotalStorage Tape Diagnostics Tool Standard Edition (ITDT-SE) and TotalStorage Tape Diagnostics Tool Graphical Edition (ITDT-GE) Version 6.0 for Linux and Windows operating system users, provide a quick and simple means to perform the following tasks:

- Run quick or extended diagnostics on tape drives.
- Start tape library self-test operations.
- Retrieve memory dumps from tape drives and libraries.
- Perform a firmware update on tape drives or libraries.
- Test the performance of the environment by completely writing a cartridge and measuring performance.
- Verify tape drive compression.
- Measure system performance.
- Retrieve and display cartridge use information.
- Verify the encryption environment. This test is used to verify whether data on the cartridge was written encrypted.
- Scan the system to discover all supported tape and library devices.
- Perform a connection test. This test is used to verify that all devices are attached properly.
- Perform a sequence of subtests to check if the tape device is defective and output a pass/fail result.

  Important: When this test is performed, all data on the cartridge is overwritten.

- Perform a full write function. This function writes the entire cartridge, which overwrites all previous data with a selectable block size that contains compressible or non-compressible data and then outputs the performance data.

  Important: When this test is performed, all data on the cartridge is overwritten.

- Perform a system test. This test writes different block sizes with compressible and non-compressible data and then outputs the performance data.

  Important: When this test is performed, all data on the cartridge is overwritten.

- Perform a tape use function to retrieve statistical data and error counters.
- Perform a manual inspect function for devices not recognized.

ITDT SE and ITDT GE provide the user with a single diagnostic program for `tapeutil` applications. Both versions contain tapeutil functionality with ITDT SE, which also provides scripting capability.

Important: The term *tapeutil* is a synonym for the tool that was delivered with the device driver. For example, this tool was named tapeutil on UNIX operating systems, but it was named ntutil on Microsoft Windows operating systems.

The ITDT-SE provides the most important functions of the previous tapeutil tools. As an extension of the current tapeutil variants, the set of operations and functions that are available with ITDT-SE is identical across all supported operating systems (unless a particular function is not available on a particular system).

Dedicated device drivers for tapes and libraries can be installed on the target system and there often is an application installed that uses the tape and library devices. When this configuration exists, ITDT-SE can coexist with the application so that when the application disables the device internally, ITDT-SE can perform the diagnostics on that device.

Important: The use of the TotalStorage Tape Diagnostic Tool on the server that is connected to the tape library is the preferred way to upgrade drive firmware on all IBM LTO tape libraries because of its speed and ease of use.

For more information about the IBM Tape Diagnostic Tool and download links, see this website:

`http://www.ibm.com/support/docview.wss?uid=ssg1S4000662`

12.2.11 IBM Ultrium Device Driver

The IBM Ultrium tape and medium changer device drivers specifically use the features that are provided by the IBM Ultrium tape drives and medium changer devices. The goal is to give applications access to the functions that are required for basic tape functions (such as backup and restore) and medium changer operations (such as cartridge mount and unmount). Applications also access the advanced functions that are needed by full tape management systems, such as Tivoli Storage Manager. Whenever possible, the drivers use the device features in a way that is not apparent to the application.

In addition, the IBM Ultrium Device Driver provides the following capabilities that are relevant to tape library management:

- Control path and Data Path Failover configuration
- Tape utility program (tape drive service aids in tape dump and firmware load)
- Error logging and the automatic memory dump facility

For more information about the latest levels of the IBM Tape Device Drivers and documentation, see this website:

http://www.ibm.com/support/fixcentral/

For a complete description of all IBM Ultrium Device Driver functionality for AIX, Linux, HP-UX, Solaris, and Windows platforms, see the *IBM Tape Device Driver Installation and Users Guide,* GC27-2130.

Control Path and Data Path Failover configuration

Before you enable alternative pathing support with the device driver, you must install the appropriate path failover feature code in the tape library. Systems with multiple paths to a tape or changer device are labeled as primary or alternative. For AIX, you can define up to 16 paths and enable them for path failover. The steps that are required to enable path failover depend upon the platform.

For more information, see the *IBM Tape Device Driver Installation and Users Guide,* GC27-2130.

The IBM tape utility program

Installed with the IBM device driver is a tape utility program, which is called `tapeutil` in AIX and Solaris, IBM `tapeutil` in Linux, and `ntutil` in Windows. This program exercises or tests the functions of the tape device (drive or media changer), and the device driver. It also performs basic tape and media changer operations. The tape utility program provides two versions: the interactive interface and the CLI.

You can use the tape utility program to access tape drive service aids from within the interactive interface. This tape utility program also provides the facilities to perform the following tasks:

- Force a memory dump
- Load firmware
- Perform error log analysis
- Device-specific commands; for example, read and write, and move media commands

Before the IBM TotalStorage Tape Diagnostic Tool was available, which now incorporates this utility, the use of using `tapeutil` often provided the simplest means of performing these tasks. However, these tasks are performed more elegantly now with TotalStorage Tape Diagnostic Tool.

Important: Use of `tapeutil` does not require root access, unlike IBM TotalStorage Tape Diagnostic Tool.

12.2.12 Summary of management capabilities

Table 12-1 summarizes that management capabilities that are available with each tool or technology.

Table 12-1 Management capabilities available with each tool or technology

Tool or technology	Set configuration	Display configuration	View errors	Send error alerts	Update firmware
Operator panel	Yes	Yes	Yes	No	No
Web UI	Yes	Yes	Yes	No	Yes
TapeAlert	No	No	No	Yes	No
SNMP	No	Yes	No	Yes	No
SMI-S	No	Yes	Yes	Yes	No
IBM Ultrium Device Driver	No	No	Yes	Yes	Yes
TotalStorage Tape Diagnostic Tool Standard Edition	No	No	No	No	Yes
TotalStorage Tape Diagnostic Tool Graphical Edition	No	No	No[a]	No	Yes

a. The Sense Bytes data is displayed during the tests while the ITDT-GE is used.

12.3 Library-specific management capabilities

The management of IBM Ultrium tape libraries is similar between models. However, certain models have other features. This section provides information about some differences between the models.

12.3.1 TS2900 tape autoloader

The TS2900 tape autoloader includes the following characteristics:

- Error messages can be sent by email.
- SNMP is supported.
- Library firmware can be updated by using the web UI.
- The Key Path Diagnostics for encryption are available.
- The LCD operator panel is controlled by buttons on the right side of the operator panel.

12.3.2 TS3100 tape library

The TS3100 tape library includes the following characteristics:

- Error messages can be sent by email.
- Library firmware can be updated by using the web UI or `tapeutil`.
- The Key Path Diagnostics for encryption are available.
- SNMP is supported.

12.3.3 TS3200 tape library

The TS3200 tape library includes the following characteristics:

- Error messages can be sent by email.
- Library firmware can be updated by using the web UI or `tapeutil`.
- The Key Path Diagnostics for encryption are available.
- SNMP is supported.

12.3.4 TS3310 tape library

The TS3310 tape library includes the following characteristics:

- Error messages can be sent by email.
- Library firmware can be updated by using the web UI.

  This library is the only library whose firmware cannot be updated by TotalStorage Tape Diagnostic Tool.
- SNMP is supported.
- Native SMI-S 1.2 support is provided.
- A CLI is supported for open system environments.
- It has a color touch-sensitive operator panel.
- Errors are grouped as Operator Intervention Messages in the Control Panel and web UI.
- The Key Path Diagnostics for encryption are available.

12.3.5 TS3500 tape library

The TS3500 tape library includes the following characteristics:

- Error messages cannot be sent by email.
- Library firmware can be updated by using the TotalStorage Tape Diagnostic Tool, `tapeutil`, or web UI.
- A CLI is supported for open system environments.
- SNMP is supported.
- SMI-S 1.2 conformance with SMI-S Agent for Tape is provided.
- Non-disruptive library firmware update is provided, which means that there is no need to bring down the library during the firmware update. A nondisruptive drive firmware update is available with firmware level 5500 or later, but it is significantly slower than the use of the TotalStorage Tape Diagnostic Tool.
- Advanced Library Management System can be configured only through the web UI.
- The Key Path Diagnostics for encryption are available.

Call Home feature

The TS3500 tape library can call an IBM Support Center when an error occurs. The library reports codes that indicate the replacement parts that might be required and the urgency of the problem. The library also can periodically send support information, such as configuration, library and drive code versions, and error logs to IBM.

The TS3500 tape library Call Home feature has the following different, but related, capabilities:

- Problem Call Home

  The TS3500 tape library or one of its drives detects a problem and the library performs a Call Home operation to create a RETAIN Problem Management Record (PMR). This single page of text data enables the IBM Support Center or the SSR to access an action plan and a list of parts called *field-replaceable units* (FRUs).

- Heartbeat Call Home

  On a scheduled basis (once a week or one hour after a code update is completed or after a power cycle), the TS3500 tape library sends home (IBM) the following files: a Machine Reported Product Data (MRPD) file, a library error log file, and a drive error log file. The MRPD file contains information about the machine (library), including the following details:

  – The number of frames and drives
  – The model and serial number of each frame
  – The type and serial number of each drive
  – The code version of the library and each drive
  – Any machine-detectable features, such as additional I/O stations and capacity expansion

A test call home also can be started from the operator panel.

When a Problem Call Home or a Heartbeat Call Home is started, the TS3500 tape library also sends data files that might be helpful to IBM Support Center personnel. If a Heartbeat Call Home occurs, the library also sends the library error log and drive error log. If a Problem Call Home occurs, the library sends any trace files that might be related to the problem.

Call Home is provided by a no-charge feature (FC2710 Remote Support Facility), which provides a modem and cable 15.2 m (50 ft.). The client must provide an analog phone line to use the Call Home feature. This phone line must be within 15.2 m (50 ft.) of the library. For more information about Call Home, see 10.3.2, “Remote support” on page 338.

12.4 Preferred practices

When library management is performed, the following preferred practices should be considered:

- Every library should be connected to the network to take advantage of the Remote Management capability and web UI. This method is the only way to access certain functionality on each library and it provides an effective means of monitoring and managing the library.
- Keep the library and drive firmware up-to-date. Firmware updates correct errors and add functionality to the operator panel menus and web UI. If you encounter a library or drive error and must call IBM Support, the representative is likely to ask you to upgrade to the latest firmware if you have not already done so. Achieving resolution is assisted by already being up-to-date with firmware levels.
- Securing web access to the web UI of the TS3500 tape library must be enabled. It is already enabled on the other library models, which means that a login ID and password are needed to access the web UI.
- For libraries in an insecure area, access to the operator panel should be secured by requiring users to log in.

- TotalStorage Tape Diagnostic Tool should be installed and used to upgrade the drive firmware where possible. This method is the fastest way to update drive firmware on all tape libraries.
- The nondestructive library firmware update that is available through the web UI should be used on the TS3500 tape library. For the TS3500, use of the TotalStorage Tape Diagnostic Tool firmware update option requires taking the library offline.
- Call Home should be used if you have a TS3500 tape library. The service is free. (An analog line must be provided by the customer). It also provides an effective means of monitoring the library.
- Data and Control Path Failover and load balancing should be used where possible for operating systems that use the IBM Tape Device Driver.
- Care should be taken to ensure the operating environment meets the specifications. In addition to temperature and humidity tolerances, ensure that the library is in an area that is free of airborne particulate matter.
- Use only supported media. IBM Ultrium tape drives are reliable, but the use of uncertified media can damage drives. Also, the use of unsupported media can invalidate the maintenance contract. For a list of certified media, see this website:

  http://www.ibm.com/systems/storage/media/

Part 3

Appendixes

This part includes material that is related to the topics in this book.

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A

IPv6 support

The TS4500, TS3500, TS3400, TS3310, TS3200, and TS3100 tape libraries; the TS2900 tape autoloader; and the TS1120 Model C06 Controller support IPv4 and IPv6 transportation. This appendix provides information about the IPv6 concept and address format compared with IPv4 and provides an IPv6 supported list of tape library products. It also includes an example of a configuration of IPv4 and IPv6 on the TS3100 tape library.

This appendix includes the following sections:

- Introduction to IPv6
- TS3100 network configuration

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Introduction to IPv6

Internet Protocol Version 6 (IPv6) is a network layer for packet-switched Internetworks. It is designated as the successor to IPv4 (the current version of the Internet Protocol) for general use on the Internet.

By the early 1990s, it was clear that the change to a classless network that was introduced a decade earlier was not enough to prevent IPv4 address exhaustion and that more changes to IPv4 were needed. By the beginning of 1992, several proposed systems were being circulated. By the end of 1992, the Internet Engineering Task Force (IETF) announced a call for white papers (RFC 1650) and the creation of IP, the Next Generation (IPng Area) of working groups.

IPng was adopted by the IETF on July 25, 1994 with the formation of several IP Next Generation (IPng) working groups. By 1996, a series of RFCs were released that defined IPv6, starting with RFC 2460.

IPv4 and IPv6 address formats

The primary change from IPv4 to IPv6 is the length of network addresses. IPv6 addresses are 128-bits long (as defined by RFC 4291). IPv4 addresses are 32-bits long. The IPv4 address space contains roughly 4,000,000,000 addresses, but IPv6 has enough room for 340 undecillion unique addresses.

An IPv4 address features the following format: *x . x . x . x*, where *x* is called an *octet* and must be a decimal value 0 - 255. Octets are separated by periods. An IPv4 address must contain three periods and four octets, as shown in the following examples:

- 1 . 2 . 3 . 4
- 01 . 102 . 103 . 104

An IPv6 address can have the following formats:

- Normal: Pure IPv6 format
- Dual: IPv6 plus IPv4 formats (not used in this release)

Normal IPv6 address

An IPv6 (normal) address features the following format: *y : y : y : y : y : y : y : y,* where *y* is called a *segment* and can be any hexadecimal value between 0 and FFFF. The segments are separated by colons, not periods. An IPv6 normal address must have eight segments. However, a short-form notation can be used by the Tape Library Specialist web interface for segments that are zero or those segments that have leading zeros. The short-form notation cannot be used from the operator panel.

The following IPv6 (normal) addresses are valid examples:

- 2001 : db8 : 3333 : 4444 : 5555 : 6666 : 7777 : 8888
- 2001 : db8 : 3333 : 4444 : CCCC : DDDD : EEEE : FFFF
- : : (implies all eight segments are zero)
- 2001: db8: : (implies that the last six segments are zero)
- : : 1234 : 5678 (implies that the first six segments are zero)
- 2001 : db8: : 1234 : 5678 (implies that the middle four segments are zero)
- 2001:0db8:0001:0000:0000:0ab9:C0A8:0102 (can be compressed to eliminate leading zeros, as in the example 2001:db8:1::ab9:C0A8:102)

An IPv6 (dual) address combines an IPv6 and an IPv4 address and features the following format: *y : y : y : y : y : y : x . x . x . x*. The IPv6 portion of the address (which is indicated with *y*) always is at the beginning, followed by the IPv4 portion (which is indicated with *x*).

The following IPv6 (dual) address values are featured:

- In the IPv6 portion of the address, *y* is a segment and can be any hexadecimal value between 0 and FFFF. The segments are separated by colons, not periods. The IPv6 portion of the address must have six segments. However, a short-form notation is available for segments that are zero.
- In the IPv4 portion of the address, *x* is an octet and must be a decimal value 0 - 255. The octets are separated by periods. The IPv4 portion of the address must contain three periods and four octets.

The following IPv6 (dual) addresses are valid examples:

- 2001 : db8: 3333 : 4444 : 5555 : 6666 : 1 . 2 . 3 . 4
- : : 11 . 22 . 33 . 44 (implies all six IPv6 segments are zero)
- 2001 : db8: : 123 . 123 . 123 . 123 (implies that the last four IPv6 segments are zero)
- : : 1234 : 5678 : 91 . 123 . 4 . 56 (implies that the first four IPv6 segments are zero)
- : : 1234 : 5678 : 1 . 2 . 3 . 4 (implies that the first four IPv6 segments are zero)
- 2001 : db8: : 1234 : 5678 : 5 . 6 . 7 . 8 (implies that the middle two IPv6 segments are zero)

Subnet masks (IPv4) and prefix lengths (IPv6)

All IP addresses are divided into portions. One part identifies the network (the network number), and the other part identifies the specific machine or host within the network (the host number). Subnet masks (IPv4) and prefixes (IPv6) identify the range of IP addresses that make up a subnet or a group of IP addresses on the same network. For example, a subnet can be used to identify all the machines in a building, department, geographic location, or on the same local area network (LAN).

Dividing the network of an organization into subnets allows it to be connected to the Internet with a single shared network address. Subnet masks and prefixes are used when a host is attempting to communicate with another system. If the system is on the same network or subnet, it attempts to find that address on the local link. If the system is on a different network, the packet is sent to a gateway, which then routes the packet to the correct IP address, which is called *Classless-InterDomain Routing* (CIDR).

In IPv4, the subnet mask 255.255.255.0 is 24 bits and consists of four, 8-bit octets. The address 10.10.10.0, with subnet mask 255.255.255.0, means that the subnet is the range of IP addresses 10.10.10.0–10.10.10.255.

The prefix-length in IPv6 is the equivalent of the subnet mask in IPv4. However, instead of expressed in four octets as it is in IPv4, it is expressed as the integer 1–128. For example: 2001:db8:abcd:0012::0/64 specifies a subnet with the range of IP addresses *2001:db8:abcd:0012*:0000:0000:0000:0000–*2001:db8:abcd:0012*:ffff:ffff:ffff:ffff. The portion in italics is called the *network portion* of the IP address, or the prefix. The portion that is not in italics is called the *host portion* of the IP address because it identifies an individual host on the network.

IPv6 functionality

To support this functionality, changes were made to the following components:

- Ethernet driver

  The Ethernet driver was modified to support an IPv4 or IPv6 link layer configuration.

- Network Manager

  The IP stack configuration can be IPv4 or IPv6, which includes IP addresses, subnet masks, and gateway addresses.

- Operator panel

  The operator panel allows the Ethernet connection to be configured as IPv4 or IPv6.

- Call Home

  Call Home determines the IP version used and presents the correct IP address and parameters to the IP Stack.

- Key proxy

  The key proxy determines the IP version that is used and presents the correct IP address and parameters to the IP Stack.

- Nonvolatile random access memory (NVRAM)

  NVRAM stores the IPv4 and IPv6 IP and gateway addresses and the network masks for both. Functions were provided to set and get the parameters.

- Vital product data (VPD) cache

  The VPD cache contains the IPv4 and IPv6 IP and gateway addresses and the network masks for both. Functions were provided to set and get the parameters.

- Web user interface (web UI)

  The pages that contain IP addresses now provide provisions for IPv4 and IPv6 formats. For example, the page that contains the IP address for the External Key Manager provides IPv4 and IPv6 formats.

Interoperability of applications

Most of the mechanisms of IPv6 transition were developed to connect IPv4 networks with IPv6 networks and base their operations in entities. These entities are at an intermediate point of the network to perform a type of processing, such as tunnels or translation of protocols.

IPv6 supported list of IBM tape LIbrary products

The following IBM tape library products can support IPv6:

- TS4500
- TS3500
- TS3400
- TS3310
- TS3200
- TS3100
- TS2900
- TS1120 Model C06

TS3100 network configuration

This section provides an example of TS3100 network configuration for Dual Stacked IPv4 and IPv6. The web UI hosts a dedicated, protected Internet site that shows a graphical representation of a library. First, you establish a connection to the library. Then, you open any HTML browser and enter the IP address of the library. To configure the web UI, you must set the IP address. The library supports IPv4, IPv6, or Dual Stack IPv4 + IPv6 transportation.

For IPv6, you enter your library static IP address or router-assigned IP address in the format `http://[0:0:0:0:0:0:0:0]`. To determine your router-assigned IP address, click **Monitor** → **Library** → **Network** on the operator control panel. For the IPv6 router that is assigned addresses to be displayed on the operator control panel, configure Network to IPv6 only and set Stateless Autoconfig to ON. Figure A-1 shows the Network Configuration panel view from the web UI.

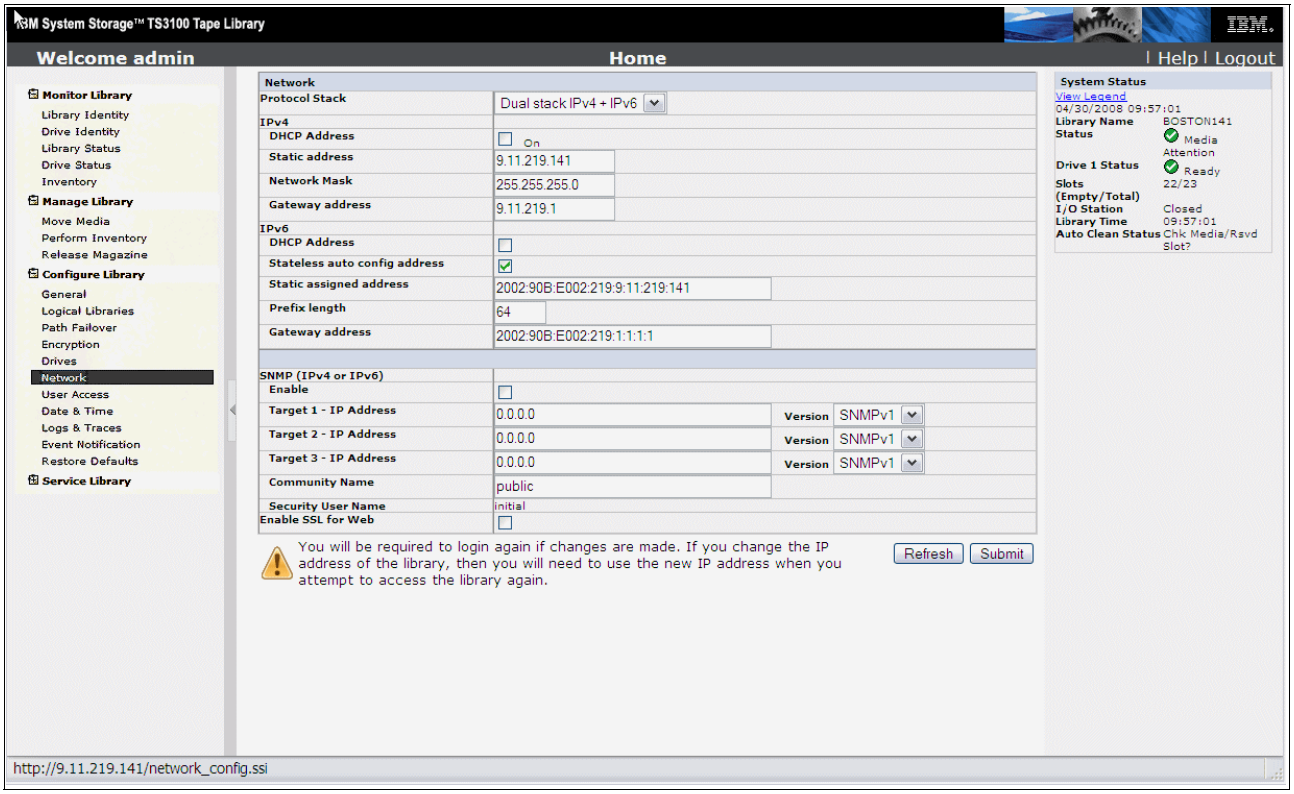


Figure A-1 Network Configuration panel

For more information about IPv6, see the following resources:

- IBM IPv6 certification page:

  `http://www.ibm.com/software/info/ipv6/index.jsp`
- Converting IPv4 programs to IPv6 (C/C++):

  `http://www.ibm.com/developerworks/web/library/wa-ipv6.html`
- Java (Java Runtime Edition (JRE) 1.4 and later must have IPv6 compliance):

  `http://docs.oracle.com/javase/7/docs/technotes/guides/net/ipv6_guide/`

B

IBM LTO Ultrium and 3592 media

When an IBM tape library is ordered, it is supplied with one Ultrium data cartridge or one 3592 data cartridge and one cleaning cartridge at no charge. Each member of the IBM 35*xx* and TS3*xxx* tape library family has different media features and rules that apply when the order is placed. The information in this appendix assists you when you are ordering more media.

To order media for your Ultrium or 3592 tape drives, see the following IBM storage media authorized distributors website:

`http://www.ibm.com/servers/storage/media/distributors/index.html`

On this page, select your location to view a list of authorized distributors.

For a list of other features for IBM LTO Ultrium and 3592 supply data cartridges with bar code labels that are separately delivered to the data cartridges, see “Features available with the initial IBM hardware order” on page 450. The value of bar code labels cannot be predetermined. For cartridges with predefined bar code labels and predetermined bar code values, order cartridges from an IBM reseller (see Table B-9 on page 463).

Media suppliers can supply tape cartridges from various manufacturers or offer a choice of brands. The tape cartridges that you use must be manufactured by a qualified Linear Tape-Open (LTO) media company to meet LTO standards.

This appendix includes the following topics:

- Features available with the initial IBM hardware order
- IBM 3589 LTO Ultrium tape cartridges
- Bar code labels
- IBM 3599 tape cartridges
- Labeling service

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Features available with the initial IBM hardware order

The following media features are available for inclusion with the initial hardware order. All media and cleaning cartridges are warranted separately from the IBM Ultrium hardware.

IBM stand-alone tape drives

- IBM TS2240 tape drive

  Part number 95P2020 or feature code 8405 provides a pack of five Ultrium 4 data cartridges.

- IBM TS2340 tape drive

  Part number 95P4278 or feature code 8405 provides a pack of five Ultrium 4 data cartridges.

- IBM TS2250 tape drive

  Part number 46C2084 or feature code 8505 provides a pack of five Ultrium 5 data cartridges.

- IBM TS2350 tape drive

  Part number 46C2084 or feature code 8505 provides a pack of five Ultrium 5 data cartridges.

- IBM TS2260 tape drive

  Part number 39P1901 or feature code 8605 provides a pack of five Ultrium 6 data cartridges.

- IBM TS2360 tape drive

  Part number 39P1901 or feature code 8605 provides a pack of five Ultrium 6 data cartridges.

IBM TS2900 tape autoloader

The following chargeable features provide media with the TS2900 tape autoloader and are available with the initial order:

- Part number 95P4278 or feature code 8405 provides a pack of five Ultrium 4 data cartridges.
- Part number 46C2084 or feature code 8505 provides a pack of five Ultrium 5 data cartridges.
- Part number 39P1901 or feature code 8605 provides a pack of five Ultrium 6 data cartridges.
- Feature code 8002 provides a single Ultrium cleaning cartridge. For the High Volume sellers, the cleaning cartridge must be ordered by using part number 23R7008.

IBM TS3100 tape library

The following chargeable features provide media with the TS3100 tape library and are available with the initial order:

- Feature code 8405 provides a pack of five Ultrium 4 data cartridges.
- Feature code 8505 provides a pack of five Ultrium 5 data cartridges.
- Feature code 8605 provides a pack of five Ultrium 6 data cartridges.

IBM TS3200 tape library

The following chargeable features provide media with the TS3200 tape library and are available with the initial order:

- Feature code 8405 provides a pack of five Ultrium 4 data cartridges.
- Feature code 8505 provides a pack of five Ultrium 5 data cartridges.
- Feature code 8605 provides a pack of five Ultrium 6 data cartridges.

IBM TS3310 tape library

For more information about ordering media supplies for the TS3310 tape library, see “IBM 3589 LTO Ultrium tape cartridges” on page 451.

IBM TS3500 tape library

For more information about ordering media supplies for the TS3500 tape library, see “IBM 3589 LTO Ultrium tape cartridges” on page 451 and “IBM 3599 tape cartridges” on page 456.

IBM TS4500 tape library

For more information about ordering media supplies for the TS4500 tape library, see “IBM 3589 LTO Ultrium tape cartridges” on page 451 and “IBM 3599 tape cartridges” on page 456.

IBM 3589 LTO Ultrium tape cartridges

To ensure that the IBM Ultrium tape drive conforms to the IBM specification for reliability, use only IBM LTO Ultrium tape cartridges. IBM TotalStorage LTO Ultrium Data Cartridges cannot be interchanged with the media that is used in other IBM non-LTO Ultrium tape products.

Table B-1 shows the generations of IBM TotalStorage Ultrium data cartridges identified by color.

Table B-1 LTO Ultrium data cartridges identified by color

Data cartridge	Case color
Ultrium 6 WORM	Black and silvery gray
Ultrium 6	Black
Ultrium 5 WORM	Burgundy and silvery gray
Ultrium 5	Burgundy
Ultrium 4 WORM	Green top; platinum (silvery gray bottom)
Ultrium 4	Green
Ultrium 3 WORM	Blue top; platinum (silvery gray bottom)
Ultrium 3	Blue
Ultrium 2	Purple
Ultrium 1	Black

All six generations contain ½-inch, dual-coat, metal-particle tape. Table B-2 shows the native capacity of Ultrium data cartridges.

Table B-2 Native capacity of the Ultrium data cartridges

Data cartridge	Native data capacity
Ultrium 6 WORM	2.5 TB (6.25 TB at a 2.5:1 compression ratio)
Ultrium 6	2.5 TB (6.25 TB at a 2.5:1 compression ratio)
Ultrium 5 WORM	1.5 TB (3.0 TB at a 2:1 compression ratio)
Ultrium 5	1.5 TB (3.0 TB at a 2:1 compression ratio)
Ultrium 4 WORM	800 GB (1600 GB at a 2:1 compression ratio)
Ultrium 4	800 GB (1600 GB at a 2:1 compression ratio)
Ultrium 3 WORM	400 GB (800 GB at a 2:1 compression ratio)
Ultrium 3	400 GB (800 GB at a 2:1 compression ratio)
Ultrium 2	200 GB (400 GB at a 2:1 compression ratio)
Ultrium 1	100 GB (200 GB at a 2:1 compression ratio)

Cartridge compatibility

Table B-3 shows the compatibility of all generations of Ultrium cartridges in an Ultrium 6 tape drive.

Table B-3 Ultrium data cartridge compatibility in an Ultrium 6 tape drive

IBM Ultrium tape drive	IBM TotalStorage LTO Ultrium Data Cartridge					
	2.5 TB (Ultrium 6)	1.5 TB (Ultrium 5)	800 GB (Ultrium 4)	400 GB (Ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 6	Read/Write	Read/Write	Read only			
Ultrium 5		Read/Write	Read/Write	Read only		
Ultrium 4			Read/Write	Read/Write	Read only	
Ultrium 3				Read/Write	Read/Write	Read only
Ultrium 2					Read/Write	Read/Write
Ultrium 1						Read/Write

Model description and ordering media supplies

This section includes two tables to help you easily find the media description and several methods that can be used to order the media.

Table B-4 lists the models of the IBM TotalStorage Tape Media 3589 for use with IBM Ultrium tape drives. IBM 3589 now supports volume serial (VOLSER) labels with embedded radio-frequency identification (RFID)-enabled bar code labels, which store and allow remote retrieval of VOLSER information. RFID labels contain a 216-bit unique pre-programmed field and a 256-bit user-defined field. These RFID labels work with most standard asset tracking and management software.

Table B-4 3589 media (20-pack)

Model	Description	Media identifier	Feature code
3589-02	IBM Ultrium 1 cartridge (100 GB) with labels	L1	FC2020
3589-03	IBM Ultrium 1 cartridge (100 GB) without labels		FC3020
3589-06	IBM Ultrium 2 cartridge (200 GB) with labels	L2	FC6020
3589-07	IBM Ultrium 2 cartridge (200 GB) without labels		FC7020
3589-08	IBM Ultrium 3 cartridge (400 GB) with labels	L3	FC0820
3589-09	IBM Ultrium 3 cartridge (400 GB) without labels		FC0920
3589-10	IBM Ultrium 4 cartridge (800 GB) with labels	L4	FC1020
3589-11	IBM Ultrium 4 cartridges (800 GB) without labels		FC1120
3589-14	IBM Ultrium 5 cartridge (1.5 TB) with labels	L5	FC1420
3589-15	IBM Ultrium 5 cartridges (1.5 TB) without labels		FC1520
3589-550	IBM Ultrium 6 cartridge (2.5 TB) with labels	L6	FC5500
3589-650	IBM Ultrium 6 cartridges (2.5 TB) without labels		FC6500
3589-28	IBM Ultrium 3 WORM cartridge (400 GB) with labels	LT	FC2820
3589-29	IBM Ultrium 3 WORM cartridge (400 GB) without labels		FC2920
3589-32	IBM Ultrium 4 WORM cartridge (800 GB) with labels	LU	FC3220
3589-33	IBM Ultrium 4 WORM cartridge (800 GB) without labels		FC3320
3589-34	IBM Ultrium 5 WORM cartridge (1.5 TB) with labels	LV	FC3420
3589-35	IBM Ultrium 5 WORM cartridge (1.5 TB) without labels		FC3520
3589-570	IBM Ultrium 6 WORM cartridge (2.5 TB) with labels	LW	FC5700
3589-670	IBM Ultrium 6 WORM cartridge (2.5 TB) without labels		FC6700

The following selection of 3589 models includes a 20-pack of labeled LTO Ultrium data cartridges and Write Once Read Many (WORM) data cartridges. These cartridges support RFID labels and are used in LTO Ultrium tape drive products:

- Model 002: 100 GB labeled Ultrium tape cartridges
- Model 006: 200 GB labeled Ultrium tape cartridges
- Model 008: 400 GB labeled Ultrium tape cartridges
- Model 010: 800 GB labeled Ultrium tape cartridges

- Model 014: 1.5 TB labeled Ultrium tape cartridges
- Model 550: 2.5 TB labeled Ultrium tape cartridges
- Model 028: 400 GB labeled Ultrium WORM tape cartridges
- Model 032: 800 GB labeled Ultrium WORM tape cartridges
- Model 034: 1.5 TB labeled Ultrium WORM tape cartridges
- Model 570: 2.5 TB labeled Ultrium WORM tape cartridges

With the media identifier, the following type of cartridge is identified:

- Media identifier L1 is an Ultrium 1 cartridge.
- Media identifier L2 is an Ultrium 2 cartridge.
- Media identifier L3 is an Ultrium 3 cartridge.
- Media identifier L4 is an Ultrium 4 cartridge.
- Media identifier L5 is an Ultrium 5 cartridge.
- Media identifier L6 is an Ultrium 6 cartridge.
- Media identifier LT is an Ultrium 3 WORM cartridge.
- Media identifier LU is an Ultrium 4 WORM cartridge.
- Media identifier LV is an Ultrium 5 WORM cartridge.
- Media identifier LW is an Ultrium 6 WORM cartridge.

Table B-5 shows the media supplies. To find the closest IBM-authorized distributor, call 1-888-IBM-MEDIA or see the IBM Storage media page at this website:

http://www.ibm.com/storage/media

Table B-5 Media supplies

Item type	Description	Quantity	Order by machine type or model from an IBM sales representative or authorized IBM Business Partner	Order by Part Number from an IBM Authorized Distributor
Data cartridges (with labels) (Specify the VOLSER characters that you want.)	Ultrium 6	20-pack	Machine Type: 3589 Model: 550	00V7590L
	Ultrium 5	20-pack	Machine Type: 3589 Model: 014	46X1953 (color label) 46X1951 (black and white label)
	Ultrium 4	20-pack	Machine Type: 3589 Model: 010	95P4443 (color label) 95P4445 (black and white label)
	Ultrium 3	1	Machine Type: 3589 Model: 008	96P1470 (color label) 96P1471 (black and white label)
Data cartridges (without labels) Order VOLSER labels separately (for more information, see “Bar code labels” on page 455).	Ultrium 6	20-pack	Machine Type:3589 Model:650	00V7590
	Ultrium 6	5-pack		35P1902
	Ultrium 5	20-pack	Machine Type: 3589 Model: 015	46X1960
	Ultrium 5	5-pack		46C2084
	Ultrium 4	20-pack	Machine Type: 3589 Model: 011	95P4447
	Ultrium 3	1	Machine Type: 3589 Model: 009	24R1922
	Ultrium 2	1	Machine Type: 3589 Model: 007	

Item type	Description	Quantity	Order by machine type or model from an IBM sales representative or authorized IBM Business Partner	Order by Part Number from an IBM Authorized Distributor
WORM cartridges (with labels) (Specify the VOLSER characters that you want.)	Ultrium 6	20-pack	Machine Type: 3589 Model: 570	00V7591L
	Ultrium 5	20-pack	Machine Type: 3589 Model: 034	46X1965 (color label) 46X1963 (black and white label)
	Ultrium 4	20-pack	Machine Type: 3589 Model: 032 WORM cartridges labeled with starting volume serial information and, optionally, packed in individual jewel cases.	95P4457 (color label) 95P4459 (black and white label)
	Ultrium 3	20-pack	Machine Type: 3589 Model: 028 WORM cartridges labeled with starting volume serial information and, optionally, packed in individual jewel cases.	
WORM cartridges (without labels) Order VOLSER labels separately (for more information, see “Bar code labels” on page 455).	Ultrium 6	20-pack	Machine Type: 3589 Model: 670	00V7591
	Ultrium 5	20-pack	Machine Type: 3589 Model: 035	46X1972
	Ultrium 4	20-pack	Machine Type: 3589 Model: 033	95P4461
	Ultrium 3	20-pack	Machine Type: 3589 Model: 029 Feature Core 2920 WORM cartridges packed in individual jewel cases with unattached blank labels.	
Cleaning Cartridge (with label)	Universal Cleaning Cartridge	5-pack	Machine Type: 3589 Model: 004 Feature Core 4005	35L2086
Repair Tools	Leader Pin Reattachment Kit	1	Not available in the sales channel	08L9129
	Manual Rewind Tool	1	Not available in the sales channel	08L9130

Bar code labels

The LTO Ultrium 6 tape drives do not require cartridge bar code labels. However, if you use your data cartridges or cleaning cartridges in an IBM tape library product, you might need

cartridge bar code labels if your tape library product requires them. You can order these labels separately from the IBM Data Cartridges and Cleaning Cartridges.

You can order bar code labels directly from the authorized label suppliers that are listed in Table B-9 on page 463.

IBM 3599 tape cartridges

This section provides information about how to order media supplies, including feature codes and part numbers for ordering media supplies for 3592 tape drives. Selected media supplies can be ordered by using feature codes when a 3592 drive is purchased. This method is the pack-in method of ordering, and the media is shipped with the hardware order. Not all media types are available with this method.

The 3599 tape media method is available for ordering all types of data and cleaning cartridges. This method is typically used for ordering larger quantities and for ordering initialized and pre-labeled cartridges. Media supplies also can be ordered by using part numbers through distributors that are authorized by IBM.

Model description

For clients who order media by using the 3599 tape media method, with IBM TotalStorage Enterprise Tape Media 3599, you can order unlabeled, pre-labeled, initialized, and bulk-packaged tape data cartridges. You can order them in various combinations. You also can order cleaning cartridges for the 3592-J1A, TS1150, TS1140, TS1130, and TS1120 tape drives.

Each 3592 data cartridge contains a passive, contactless, silicon storage device called cartridge memory (CM). The CM module holds information about that specific cartridge, the media in the cartridge, and the data on the media. The cartridge and media information is stored in a protected, read-only area of the CM. When the cartridge is loaded into the drive, a CM reader in the drive uses a contactless, radio-frequency interface to read the information. Each cleaning cartridge also contains a CM module, which tracks the number of cleaning uses and the location of the used cleaning media.

Cartridge capacity depends on the following recording formats of the tape drive that is writing the cartridges:

- TS1150 can write in Enterprise Format 5 (EFMT5) and in Enterprise Format 4 (EFMT4). Models E08 and EH8 can also write in Enterprise Encrypted Format 5 (EEFMT5) and Enterprise Encrypted Format 4 (EEFMT4), an encrypted format, which does not change the capacity of the cartridge compared to the non-encrypted format.
- TS1140 can write in Enterprise Format 4 (EFMT4) and in Enterprise Format 3 (EFMT3). Models E07 and EH7 can also write in Enterprise Encrypted Format 4 (EEFMT4) and Enterprise Encrypted Format 3 (EEFMT3), an encrypted format, which does not change the capacity of the cartridge compared to the non-encrypted format.
- TS1130 can write in the EFMT3 and in EFMT2 format. Models E06 can also write in an encrypted format EEFMT3 and EEFMT2, which does not change the capacity of the cartridge compared to the non-encrypted format
- TS1120 writes in EFMT1 or EFMT2 format, and the E05 also can write in an encrypted format EEFMT2, which does not change the capacity of the cartridge compared to the non-encrypted format.
- 3592-J1A writes in EFMT1 only.

3592 media types

The TS1150 tape drive uses the Advanced Data (type JD) and Advanced WORM (type JZ) cartridges. The type JD and JZ cartridges have a maximum capacity of 10000 GB.

TS1150 and TS1140 tape drives uses the Advanced Data (type JC) and Advanced WORM (type JY) cartridges. The type JC and JY cartridges have a maximum capacity of 4000 GB in EFMT4 format and 7000 GB in EFMT 5 format.

Tape drive TS1140, TS1130, TS1120 all can use 3592 Extended Data (type JB) and Extended WORM (type JX) with a maximum capacity of 1600 GB that uses the EFMT4 format, 1000 GB that uses the EFMT3 format, and 700 GB that uses the EFMT2 format. The 3592 E07 tape drive can read format EFMT2 only.

Tape drive TS1130, TS1120, and 3592 JIA use 3592 Standard Data (type JA) and Standard WORM (type JW) cartridges with a maximum capacity of 640 GB that uses EFMT3 format, 500 GB that uses EFMT2 format, and 300 GB that uses EFMT1 format. The TS1140 tape drive does support cartridge types JA and JW in read-only on any format.

Tape drive TS1130, TS1140, and 3592 JIA use 3592 Economy Data (type JJ) and Economy WORM (type JR) cartridges with a maximum capacity of 128 GB that uses EFMT3 format, 100 GB that uses EFMT2 format, and 60 GB that uses EFMT1 format. The 3592 E07 tape drive support cartridge types JJ and JR in read-only on any format.

The 3592 E07 and E08 tape drive uses the 3592 Advanced Economy (type JK) cartridge with a maximum capacity of 500 GB that uses EFMT4 format and 900 GB in EFMT 5 format,

The 3592 E08 tape drive uses the 3592 Advanced Economy (type JL) cartridge with a maximum capacity of 2000 GB in EFMT 5 format,

Ordering 3592 media

If you order media by using the 3599 tape media method, IBM TotalStorage Enterprise Tape Media 3599 you can order unlabeled, pre-labeled, initialized, and bulk-packaged data cartridges in various combinations. You also can order cleaning cartridges. Table B-6 shows a list of data cartridges that can be ordered by using the 3599 tape media method.

Table B-6 3599 media feature description

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity	Description
		Regular	RFID			
011	JA/9030	1020	1021	9082	640 GB	3592 Enterprise Tape Cartridge labeled and initialized
				9081	500 GB	
				9080	300 GB	
012	JA/9030	2020	2021	N/A	500 GB	3592 Enterprise Tape Cartridge labeled and not initialized
					300 GB	
013	JA/9030	3020	N/A	N/A	500 GB	3592 Enterprise Tape Cartridge not labeled and not initialized
					300 GB	
014	JB/9032	4020	4021	9084	1600 GB	3592 Extended Tape Cartridge labeled and initialized
				9082	1000 GB	
				9081	700 GB	

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity	Description
		Regular	RFID			
015	JB/9032	5020	5021	N/A	700 GB	3592 Extended Tape Cartridge labeled and not initialized
016	JB/9032	6020	N/A	N/A	700 GB	3592 Extended Tape Cartridge not labeled and not initialized
420	JC/9035	4211	4221	9084	4 TB	3592 Advanced Tape Cartridge labeled and initialized
520	JC/9035	5221	5231	N/A	4 TB	3592 Advanced Tape Cartridge labeled and not initialized
620	JC/9035	6200	N/A	N/A	4 TB	3592 Advanced Tape Cartridge not labeled and not initialized
	JC/9035	N/A	N/A	N/A	7 TB	3592 Advanced Tape Cartridge labeled and initialized
	JC/9035	N/A	N/A	N/A	7 TB	3592 Advanced Tape Cartridge labeled and not initialized
	JC/9035	N/A	N/A	N/A	7TB	3592 Advanced Tape Cartridge not labeled and not initialized
425	JD/9036	4251	4261	9085	10 TB	3592 Advanced Tape Cartridge labeled and initialized
525	JD/9036	5251	5261	N/A	10 TB	3592 Advanced Tape Cartridge labeled and not initialized
625	JD/9036	6250	N/A	N/A	10 TB	3592 Advanced Tape Cartridge not labeled and not initialized
E11	JJ/9050	1120	1121	9082	128 GB	3592 Economy Tape Cartridge labeled and initialized
				9081	100 GB	
				9080	60 GB	
E12	JJ/9050	1220	1221	N/A	60 GB	3592 Economy Tape Cartridge labeled and not initialized
E13	JJ/9050	1320	N/A	N/A	60 GB	3592 Economy Tape Cartridge not labeled and not initialized
430	JK/9052	4300	4310	9084	500 GB	3592 Advanced Economy Tape Cartridge labeled and initialized
530	JK/9052	5300	5310	N/A	500 GB	3592 Advanced Economy Tape Cartridge labeled and not initialized
630	JK/9052	6300	N/A	N/A	500 GB	3592 Advanced Economy Tape Cartridge not labeled and not initialized
	JK/9052	N/A	N/A	N/A	900 GB	3592 Advanced Economy Tape Cartridge labeled and initialized

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity	Description
		Regular	RFID			
	JK/9052	N/A	N/A	N/A	900 GB	3592 Advanced Economy Tape Cartridge labeled and not initialized
	JK/9052	N/A	N/A	N/A	900 GB	3592 Advanced Economy Tape Cartridge not labeled and not initialized
435	JL/9054	4351	4361	9085	2 TB	3592 Advanced Economy Tape Cartridge labeled and initialized
535	JL/9054	5351	5361	N/A	2 TB	3592 Advanced Economy Tape Cartridge labeled and not initialized
635	JL/9054	6351	N/A	N/A	2 TB	3592 Advanced Economy Tape Cartridge not labeled and not initialized
021	JR/9042	3120	3121	9082	128 GB	3592 WORM Tape Cartridge labeled and initialized
				9081	100 GB	
				9080	60 GB	
022	JR/9042	3220	3221	N/A	100 GB	3592 WORM Tape Cartridge labeled and not initialized
					60 GB	
023	JR/9042	3320	N/A	N/A	100 GB	3592 WORM Tape Cartridge not labeled and not initialized
					60 GB	
021	JW/9040	2120	2121	9082	640 GB	3592 WORM Tape Cartridge labeled and initialized
				9081	500 GB	
				9080	300 GB	
022	JW/9040	2220	2221	N/A	500 GB	3592 WORM Tape Cartridge labeled and not initialized
					300 GB	
023	JW/9040	2320	N/A	N/A	500 GB	3592 WORM Tape Cartridge not labeled and not initialized
					300 GB	
024	JX/9044	2420	2421	9082	1000 GB	3592 Extended WORM Tape Cartridge labeled and initialized
				9081	700 GB	
025	JX/9044	2520	2521	N/A	700 GB	3592 Extended WORM Tape Cartridge labeled and not initialized
026	JX/9044	2620	N/A	N/A	700 GB	3592 Extended WORM Tape Cartridge not labeled and not initialized
440	JY/9046	4400	4410	9084	4 TB	3592 Advanced WORM Tape Cartridge labeled and initialized

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity	Description
		Regular	RFID			
540	JY/9046	5400	5410	N/A	4 TB	3592 Advanced WORM Tape Cartridge labeled and not initialized
640	JY/9046	6400	N/A	N/A	4 TB	3592 Advanced WORM Tape Cartridge not labeled and not initialized
	JY/9046	N/A	N/A	N/A	7TB	3592 Advanced WORM Tape Cartridge labeled and initialized
	JY/9046	N/A	N/A	N/A	7 TB	3592 Advanced WORM Tape Cartridge labeled and not initialized
	JY/9046	N/A	N/A	N/A	7 TB	3592 Advanced WORM Tape Cartridge not labeled and not initialized
445	JZ/9046	4455	4465	9085	10 TB	3592 Advanced WORM Tape Cartridge labeled and initialized
545	JZ/9046	5451	5461	N/A	10 TB	3592 Advanced WORM Tape Cartridge labeled and not initialized
645	JZ/9046	645	N/A	N/A	10 TB	3592 Advanced WORM Tape Cartridge not labeled and not initialized
017	JA	FC 7005	NA	No	N/A	5-pack 3592 Cleaning Cartridges, with media identification labels
017	JA	FC 7006	NA	No	N/A	5-pack 3592 Cleaning Cartridges, without media identification labels

With the 3599 tape media method of ordering, model numbers are used to identify the cartridge types. Feature code combinations are used to specify the quantities, labeling, and initialization options.

IBM 3599 supports VOLSER labels with embedded radio frequency identification (RFID)-enabled bar code labels, which store and allow remote retrieval of VOLSER information. RFID labels contain a 216-bit unique pre-programmed field and a 256-bit user-defined field. These RFID labels work with most standard asset tracking and management software.

Important: For cartridges that are not initialized, the actual cartridge capacity is dependent on the format that is used to write the cartridge.

Table B-7 lists the data cartridges and media supplies that you can order for the 3592 tape drives. You can use one of the following methods to order the cartridges:

- Order by part number through an IBM-Authorized distributor. For more information about the nearest distributor, see the IBM Storage media page at this website:

  http://www.ibm.com/storage/media

- If you do not have Internet access, you can order the cartridges from any authorized IBM Business Partner or your IBM marketing representative.
- Call 1-888-IBM-MEDIA.

Note: All WORM cartridges must be ordered by using their part number, as shown in Table B-7.

Table B-7 Media supplies for the 3592 drive

Supply item	Media ID	Part number
IBM 3592 Advanced Enterprise Tape Cartridge	JD	2727263
IBM 3592 Advanced Enterprise Tape Cartridge	JC	46X7452
IBM 3592 Extended Enterprise Tape Cartridge	JB	25R9830
IBM 3592 Enterprise Tape Cartridge	JA	18P7534
IBM 3592 Economy Tape Cartridge	JJ	24R0316
IBM 3592 Advanced Economy Tape Cartridge	JK	46X7453
IBM 3592 Advanced Economy Tape Cartridge	JL	2727264
IBM 3592 Economy Tape Cartridge Worm	JR	24R0317
IBM 3592 Enterprise Cartridge WORM	JW	18P7538
IBM 3592 Extended Enterprise Cartridge WORM	JX	23R9831
IBM 3592 Advanced Enterprise Cartridge WORM	JY	46X7454
IBM 3592 Advanced Enterprise Cartridge WORM	JZ	2727265
IBM TotalStorage Enterprise Data Cartridge 3592 cleaning, 50 uses	JA	18P7535

Labeling service

The labeling service applies to IBM 3589 and IBM 3599 media types that have labels, as described in the previous sections.

Six characters are in the VOLSER. IBM provides specific codes to give you the flexibility to choose where to begin the volume range that you require. The sixth character is always a 0 character because your volume serial range always must begin at a 0 boundary for labeling. Also, the labels that are supplied are sequential. For example, if you order 20 cartridges, the first cartridge is labeled with a sixth digit of 0, and the 20th cartridge is labeled with a sixth digit of 9.

The character identifier features are four-digit feature numbers in the form 9*nnn*, where:

- The first digit (9) indicates that the feature carries no charge.

- A second digit of 1, 2, 3, 4, or 5 indicates which character in the VOLSER this feature is specifying (1st, 2nd, 3rd, 4th, or 5th).
- The third and fourth digits range from 00 - 35, where 00 - 09 represent the characters 1 - 9, and 10 - 35 represent the characters A - Z.

Choose the first 1, 2, 3, 4, or 5 digits by using the following feature numbers:

- For the first alphanumeric digit (0–9 or A–Z), use FC9100 (0) to FC9135 (Z).
- For the second alphanumeric digit (0–9 or A–Z), use FC9200 (0) to FC9235 (Z).
- For the third alphanumeric digit (0–9 or A–Z), use FC9300 (0) to FC9335 (Z).
- For the fourth numeric digit (0–9), use FC9400 (0) to FC9409 (9).
- For the fifth numeric digit (0–9), use FC9500 (0) to FC9509 (9).
- The sixth numeric digit is set to 0 as standard.
- The seventh and eighth characters of the VOLSER are set based on media type. For more information, see the “Media identifier” column in Table B-4 on page 453 and “Labeling service” on page 461.

If you do not specify a feature code, the supplied starting character is a 0. Therefore, if you specify features for the first three characters as `ABC` but no more, the sequence of labels begins `ABC000`.

The following specific features indicate requirements for colored labels:

- FC9077 specifies a white background.
- FC9022 specifies a colored background for alphabetic characters.

If you specify FC9022, you can choose from 10 available colors, as shown in Table B-8.

Table B-8 Color specify feature codes for the IBM 3599

Alpha prefix background	Feature code	Alpha prefix background	Feature code
Red	9003	Orange	9008
Yellow	9004	Pink	9009
Light green	9005	Dark green	9010
Light blue	9006	Light orange	9011
Gray	9007	Purple	9012

Ordering bar code labels

You can order bar code labels from one of the authorized suppliers that are listed in Table B-9.

Table B-9 Authorized suppliers of custom bar code labels

In the Americas	In Europe and Asia
EDP/Tri-Optic 6800 West 117th Avenue Broomfield, CO 80020 USA Telephone: 888-438-8362 http://www.tri-optic.com/	EDP Europe, Ltd. 43 Redhills Road South Woodham Ferrers Chelmsford, Essex CM3 5UL UK Telephone: 44 (0) 1245-322380 http://www.edpeurope.com/en/products/media-labels-and-storage
Dataware P.O. Box 740947 Houston, TX 77274 USA Telephone: 800-426-4844 http://www.datawarelabels.com/	Dataware Labels Europe 12 Ashley Street Chatwood NSW 2067 Australia Telephone: (029) 496-1111 http://www.datawarelabels.com/
NetC 100 Corporate Drive Trumbull, CT 06611 USA Telephone: 203-372-6382 http://www.netcllc.com/	NetC Europe Ltd The Old Surgery 5a The Pavement North Curry TA3 6LX Somerset UK Telephone: 44 (0) 1823 49 1439 http://www.netclabels.co.uk
	NetC Asia Pacific Pty Ltd Postal Address: PO Box 872 Cooroy QLD 4563 Australia Telephone: 61 (0)7 5442 6263 http://www.netclabels.com.au

C

IBM tape product names

As of January 4, 2010, all products are preceded by the IBM brand name and either “TotalStorage” (for existing products) or “System Storage” (for products that were announced after October 11, 2005). Now, as products are updated, the System Storage name will be removed. Immediately following the first use of the name, the short names that are defined in the related product tables that are included in this appendix must appear in parentheses and must be used exclusively in the rest of the document. The use of the short name (for example, “machine type” or “model”) is acceptable only in diagrams or presentation material. Exceptions are tape virtualization products with names that are preceded with Virtualization Engine, library frames, and media.

This appendix includes the following sections:

- TS series family names
- TS1000 tape drives (LTO)
- TS1100 tape drive (enterprise)
- TS2000 Tape Enclosures (LTO)
- TS2900 tape autoloader
- TS3100 tape library
- TS3200 tape library
- TS3310 tape library
- TS3400 tape library
- TS3500 tape library
- TS4500 tape library
- TS7600 ProtecTIER

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TS series family names

The new TS*xxxx* series family names that are shown in Figure C-1 include the following breakdown:

- The 1000 series is reserved for tape drives, for example, the TS1140 (3592) and TS1060 (LTO Ultrium) tape drives.
- The 2000 series is reserved for storage enclosures, for example, the TS2200 and TS2300 LTO Ultrium tape drives.
- The 3000 series is reserved for automation, for example, the TS3500 tape library.
- The 4000 series is reserved for automation, for example, the TS4500 tape library.
- The 7000 series is reserved for virtualization, for example, the TS7600 Virtual tape library.

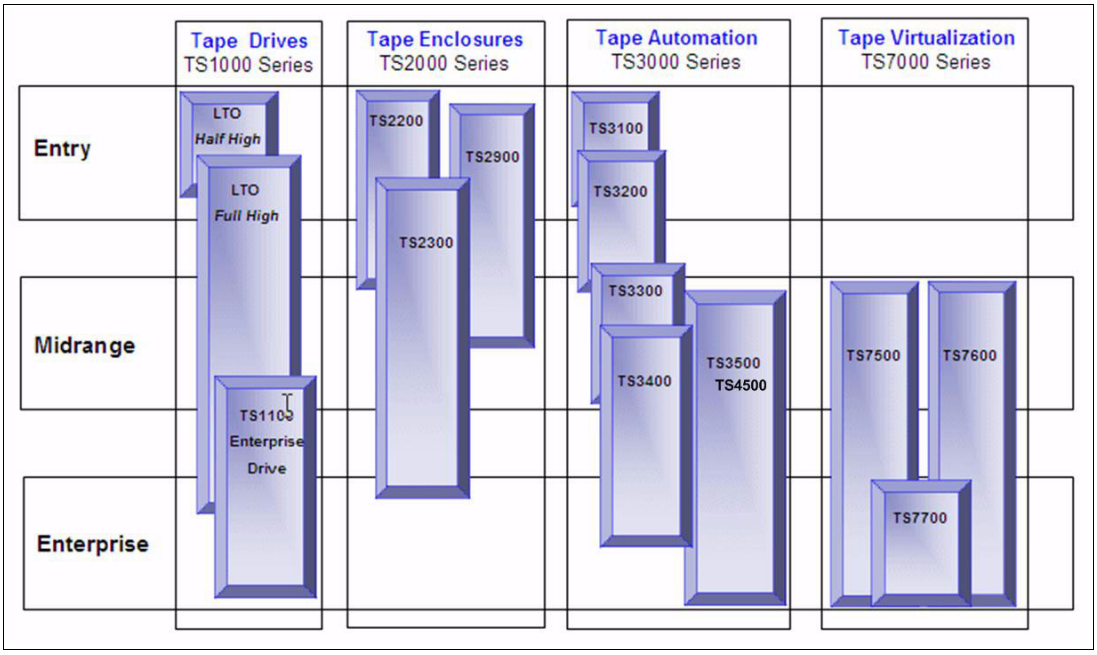


Figure C-1 IBM Tape Systems Portfolio 2010

The tables in the following sections identify the IBM tape products with the machine type and model, the new name, and a short name.

TS1000 tape drives (LTO)

Table C-1 shows the TS1000 tape drive naming conventions including machine type, model, new name, and short name.

Table C-1 TS1000 tape drive naming

M/T	Model	New name	Short name
3580		IBM TS1000 LTO tape drive Series	
3588	F3A	IBM TS1030 tape drive Model F3A	3588 F3A
	F3B	IBM TS1030 tape drive Model F3B	TS1030 LTO tape drive
	F4A	IBM TS1040 tape drive Model F4A	TS1040 LTO tape drive
	F5A	IBM TS1050 tape drive Model F5A	TS1050 LTO tape drive
	F6A	IBM TS1060 tape drive Model F6A	TS1060 LTO tape drive

TS1100 tape drive (enterprise)

Table C-2 shows the TS1100 tape drive naming conventions including machine type, model, new name, and short name.

Table C-2 TS1100 tape drive naming

M/T	Model	New name	Short name
3592			
3592	J1A		3592 J1A tape drive
	E05	IBM TS1120 tape drive Model E05	TS1120 tape drive
	E06	IBM TS1130 tape drive Model E06	TS1130 tape drive
	EU6	IBM TS1130 tape drive Model EU6	TS1130 tape drive
	E07	IBM TS1140 tape drive Model E07	TS1140 tape drive
	EH7	IBM TS1140 tape drive Model EH7	TS1140 tape drive
	E08	IBM TS1150 tape drive Model E08	TS1150 tape drive
	EH8	IBM TS1150 tape drive Model EH8	TS1150 tape drive
	C06	IBM TS1120 Tape Controller Model C06	TS1120 Tape Controller
	C07	IBM 3592 Tape Controller Model C07	3592 C07 Tape Controller
	C20	IBM 3592 Tape Frame Model C20	3592 C20 Frame

TS2000 Tape Enclosures (LTO)

Table C-3 shows the TS2000 Tape Enclosure naming conventions including machine type, model, new name, and short name.

Table C-3 TS2000 Tape Enclosures naming

M/T	Model	New names	Short name
3580		IBM TS2000 Storage Enclosures Series	
3580	H3L	IBM TS2230 tape drive Model L3E (LVD – AAS)	TS2230 tape drive
	H3S	IBM TS2230 tape drive Model H3S (SAS – AAS)	
	L3E	IBM TS2230 tape drive Model H3S (LVD – HVEC)	
	S3E	IBM TS2230 tape drive Model H3S (SAS – AAS)	
	S3V	IBM TS2230 tape drive Model H3V (SAS – AAS)	
	L43	IBM TS2340 tape drive Model L43 (LVD – AAS)	TS2340 tape drive
	S43	IBM TS2340 tape drive Model S43 (SAS – AAS)	
	L4X	IBM TS2340 tape drive Model L4X (LVD – HVEC)	
	S4X	IBM TS2340 tape drive Model S4X (SAS – HVEC)	
	S4V	IBM TS2340 tape drive Model H4V (SAS – HVEC)	
3580	H4S	IBM TS2240 tape drive Model H4S (SAS – AAS)	TS2240 tape drive
	S4E	IBM TS2240 tape drive Model S4E (SAS – HVEC)	
	E4S	IBM TS2240 tape drive Model E4E (SAS – HVEC)	
	S53	IBM TS2350 tape drive Model S53 (SAS – AAS)	TS2350 tape drive
	S5X	IBM TS2350 tape drive Model S5X (SAS – HVEC)	
	H5S	IBM TS2250 tape drive Model H5S (SAS – AAS)	TS2250 tape drive
	S5E	IBM TS2250 tape drive Model S5E (SAS – HVEC)	
	H6S	IBM TS2260 tape drive Model H6S (SAS – AAS)	TS2260 tape drive
	S6E	IBM TS2260 tape drive Model S6E (SAS – HVEC)	
	S63	IBM TS2360 tape drive Model S63 (SAS – AAS)	TS2360 tape drive
	S6X	IBM TS2360 tape drive Model S6X (SAS – HVEC)	

TS2900 tape autoloader

Table C-4 on page 469 shows the TS2900 tape autoloader naming conventions including machine type, model, new name, and short name.

Table C-4 TS2900 tape autoloader naming

M/T	Model	New name	Short names
3572		IBM TS2900 tape autoloader	TS2900 tape autoloader
3572	S3H	IBM TS2900 tape autoloader Model S3H (AAS)	
	S3R	IBM TS2900 tape autoloader Model S3R (HVEC)	
	S3E	IBM TS2900 tape autoloader Model S3E (HVEC/ seller)	
	S4H	IBM TS2900 tape autoloader Model S4H (AAS)	
	S4R	IBM TS2900 tape autoloader Model S4R (HVEC)	
	S4E	IBM TS2900 tape autoloader Model S4E (HVEC/ seller)	
	S5H	IBM TS2900 tape autoloader Model S5H (AAS)	
	S5R	IBM TS2900 tape autoloader Model S5R (HVEC)	
	S6H	IBM TS2900 tape autoloader Model S6H (AAS)	
	S6R	IBM TS2900 tape autoloader Model S6R (HVEC)	

TS3100 tape library

Table C-5 shows the TS3100 tape library naming conventions including machine type, model, new name, and short name.

Table C-5 TS3100 tape library naming

M/T	Model	New name	Short name
3573		IBM TS3100 tape library	TS3100 tape library
3573	L2U	IBM TS3100 tape library Model L2U	
	2UL	IBM TS3100 tape library Model 2UL (HVEC)	

TS3200 tape library

Table C-6 shows the TS3200 tape library naming conventions including machine type, model, new name, and short name.

Table C-6 TS3200 tape library naming

M/T	Model	New name	Short name
3573		IBM TS3200 tape library	TS3200 tape library
3573	L4U	IBM TS3200 tape library Model L4U	
	4UL	IBM TS3200 tape library Model 4UL (HVEC)	

TS3310 tape library

Table C-7 on page 470 shows the TS3310 tape library naming conventions including machine type, model, new name, and short name.

Table C-7 TS3310 tape library naming

M/T	Model	New name	Short name
3576		IBM TS3300 tape library	TS3300 tape library
3576	L5B	IBM TS3310 tape library Model L5B	L5B Module
	E9U	IBM TS3310 tape library Model E9U	E9U Module

TS3400 tape library

Table C-8 shows the TS3400 tape library naming conventions including machine type, model, new name, and short name.

Table C-8 TS3400 tape library naming

M/T	Model	New name	Short name
3577		IBM TS3400 tape library	TS3400 tape library
3577	L5U	IBM TS3400 tape library Model L5U	

TS3500 tape library

Table C-9 describes the TS3500 tape library naming conventions including machine type, model, new name, and short name.

Table C-9 TS3500 tape library naming

M/T	Model	New name	Short name
3584		IBM TS3500 tape library	TS3500 tape library
3584	L23	IBM TS3500 Model L23	TS3500 L23 Frame
	L53	IBM TS3500 Model L53	TS3500 L53 Frame
	D23	IBM TS3500 Model D23	TS3500 D23 Frame
	D53	IBM TS3500 Model D53	TS3500 D53 Frame
	S24	IBM TS3500 Model S24	TS3500 S24 Frame
	S54	IBM TS3500 Model S54	TS3500 S54 Frame
	SC1	IBM TS3500 Model SC1	TS3500 Library strings shuttle connector
	HA1	IBM TS3500 Model HA1	TS3500 High Availability Option

TS4500 tape library

Table C-10 describes the TS4500 tape library naming conventions, including machine type, model, new name, and short name.

Table C-10 TS4500 tape library naming

M/T	Model	New name	Short name
3584		IBM TS4500 tape library	TS4500 tape library
3584	L25	IBM TS4500 Model L25	TS4500 L25 Frame
	L55	IBM TS4500 Model L55	TS4500 L55 Frame
	D25	IBM TS4500 Model D25	TS4500 D25 Frame
	D55	IBM TS4500 Model D55	TS4500 D55 Frame
	S25	IBM TS4500 Model S25	TS4500 S25 Frame
	S55	IBM TS4500 Model S55	TS4500 S55 Frame

TS7600 ProtecTIER

Table C-11 describes the TS7600 ProtecTier virtual tape library naming conventions including machine type, model, new name, and short name.

Table C-11 TS7600 Virtual tape library naming

M/T	Model	New name	Short name
Solution		IBM TS7600 with ProtecTIER	TS7600
3958	DD1	IBM TS7650G ProtecTIER Deduplication Gateway	TS7650G
	DD3	IBM TS7650G ProtecTIER Deduplication Gateway	TS7650G
	DD4	IBM TS7650G ProtecTIER Deduplication Gateway	TS7650G
	DD5	IBM TS7650G ProtecTIER Deduplication Gateway	TS7650G
	AP1	IBM TS7650 ProtecTIER Deduplication Appliance	TS7650
3959	SM1	IBM TS7610 ProtecTIER Deduplication Appliance Express	TS7610
	SM2	IBM TS7620 ProtecTIER Deduplication Appliance Express	TS7620

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http://www.ibm.com/services/us/en/it-services/express-services-full-portfolio.html

D

Data storage values

This appendix describes the units of measure that are used to express data storage values in the IBM Tape Storage Products. For example, in the IBM TS3500 tape library chapter, it displays data storage values by using decimal (base-10) prefixes and binary (base-2) units of measurement.

Decimal units such as K, MB, GB, and TB are commonly used to express data storage values, although these values are more accurately expressed by using binary units, such as KiB, MiB, GiB, and TiB. At the kilobyte level, the difference between decimal and binary units of measurement is relatively small (2.4%). This difference grows as data storage values increase, and when values reach terabyte levels, the difference between decimal and binary units approaches 10%.

To reduce the possibility of confusion, this appendix represents data storage by using decimal and binary units. Data storage values are displayed by using the following format:

```
#### decimal unit (binary unit)
```

By this example, the value 512 terabytes is displayed as shown in the following example:

```
512 TB (465.6 TiB)
```

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Table D-1 compares the names, symbols, and values of the binary and decimal units.

Table D-1 Comparison of binary and decimal units and values

Decimal			**Binary**		
Name	**Symbol**	**Value (base-10)**	**Name**	**Symbol**	**Value (base-2)**
kilo	K	10^3	kibi	Ki	2^{10}
mega	M	10^6	mebi	Mi	2^{20}
giga	G	10^9	gibi	Gi	2^{30}
tera	T	10^{12}	tebi	Ti	2^{40}
peta	P	10^{15}	pebi	Pi	2^{50}
exa	E	10^{18}	exbi	Ei	2^{60}

Table D-2 shows the increasing percentage difference between binary and decimal units.

Table D-2 Percentage difference between binary and decimal units

Decimal value	**Binary value**	**Percentage difference**
100 Kilobytes (KB)	97.65 kibibytes (KiB)	2.35%
100 megabytes (MB)	95.36 mebibytes (MiB)	4.64%
100 gigabytes (GB)	93.13 gibibytes (GiB)	6.87%
100 terabytes (TB)	90.94 tebibytes (TiB)	9.06%
100 petabytes (PB)	88.81 pebibytes (PiB)	11.19%
100 exabytes (EB)	86.73 exbibytes (EiB)	13.27%

Related publications

The publications that are listed in this section are considered particularly suitable for a more detailed discussion of the topics that are covered in this IBM Redbooks publication.

IBM Redbooks publications

The following IBM Redbooks publications provide more information about the topics in this book. Some publications that are referenced in this list might be available in softcopy only:

- *Designing an IBM Storage Area Network*, SG24-5758
- *IBM System Storage Solutions Handbook*, SG24-5250
- *IBM System Storage Tape Encryption Solutions*, SG24-7320
- *IBM System Storage TS7650, TS7650G, and TS7610*, SG24-7652
- *IBM Tape Solutions for Storage Area Networks and FICON*, SG24-5474
- *IBM Tivoli Storage Manager as a Data Protection Solution*, SG24-8134
- *IBM Tivoli Storage Productivity Center V5.2 Release Guide, SG24-8204*
- *IBM TotalStorage Enterprise Tape 3592: Presentation Guide*, REDP-3749
- *IBM TS3500 Tape Library with System z Attachment A Practical Guide to Enterprise Tape Drives and TS3500 Tape Automation*, SG24-6789
- *IBM TS4500 Tape Library Guide*, SG24-8235
- *Implementing IBM Tape in i5/OS*, SG24-7440
- *Implementing IBM Tape in Linux and Windows*, SG24-6268
- *Implementing IBM Tape in UNIX Systems*, SG24-6502
- *iSeries in Storage Area Networks: A Guide to Implementing FC Disk and Tape with iSeries*, SG24-6220
- *The LTO Ultrium Primer for IBM eServer iSeries Customers*, REDP-3580
- *Tivoli Storage Manager V6.1 Technical Guide*, SG24-7718
- *Linear Tape File System: Installation and Configuration*, SG24-8090
- *Linear Tape File System Enterprise Edition V1.1.1.2 Installation and Configuration Guide*, SG24-8143

You can search for, view, download, or order these publications and other Redbooks, IBM Redpapers, Web Docs, draft, and other materials at the following website:

`http://www.ibm.com/redbooks`

Other publications

The following publications also are relevant as further information sources:

- *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference*, GA32-0450
- *IBM Tape Device Drivers Programming Reference*, GA32-0566

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- *IBM Tape Device Drivers Installation and User's Guide,* GC27-2130
- *IBM TotalStorage 3580 Tape Drive Setup, Operator, and Service Guide*, GC26-7708
- *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470
- *IBM TotalStorage 3581 Tape Autoloader Setup, Operator and Service Guide*, GA32-0461
- *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458
- *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411
- *IBM System Storage TS2230 Tape Drive Setup, Operator and Service Guide,* GC27-2099
- *BM System Storage TS2240 Tape Drive Setup, Operator and Service Guide,* GC27-2151
- *IBM System Storage TS2340 Tape Drive Setup, Operator and Service Guide*, GC27-2103
- *IBM System Storage TS2250 Tape Drive Setup, Operator and Service Guide*, GC27-2275
- *IBM System Storage TS2350 Tape Drive Setup, Operator and Service Guide,* GC27-2277
- *IBM System Storage TS2360 Tape Drive Setup, Operator and Service Guide,* GA32-2228
- *IBM System Storage TS2900 Tape Autoloader Setup, Operator and Service Guide,* GC27-2212
- *IBM System Storage TS3100 Tape Library and TS3200 Tape Library Setup, Operator, and Service Guide*, GA32-0545
- *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477
- *IBM System Storage TS3310 Tape Library Maintenance Information for IBM Service Personnel,* GA32-0478
- *IBM System Storage TS3310 Tape Library SCSI Reference,* GA32-0476
- *IBM System Storage TS3400 Planning and Operator Guide,* GC27-2107
- *IBM System Storage TS3500 Tape Library Introduction and Planning Guide IBM 3584 Tape Library*, GA32-0559
- *IBM System Storage TS3500 Tape Library with ALMS Introduction and Planning Guide*, GA32-0593
- *IBM Tape Library with ALMS Operator Guide*, GA32-0594
- *IBM System Storage TS7600 with ProtecTIER Introduction and Planning Guide*, GC53-1193
- *IBM System Storage TS7600 with ProtecTIER Introduction and Planning Guide for the 3958 DD4*, GC53-1152
- *IBM System Storage TS7600 with ProtecTIER Problem Determination Guide for the TS7650 and TS7650G*, GC53-1157
- *IBM System Storage TS7600 with ProtecTIER User's Guide*, GC53-1156
- *IBM System Storage Tape Library Operator Guide*, GA32-0560
- *IBM System Storage 3592 Tape Drives and TS1120 Controller Operator Guide for 3592 Models J1A, E05, E06, EU6, E07, J70 and C06*, GA32-0556
- *IBM System Storage 3592 Tape Drive and Controller Introduction and Planning Guide 3592 Models E06, EU6, E07/EH7, E08/EH8*, GA32-0555

Online resources

The following websites and URLs also are relevant as further information sources:

- IBM Linear Tape-Open Technology (LTO) products

  http://www.ibm.com/storage/lto

- LTO Technology Organization website for information about the technology, formats, and licensing

  http://www.lto-technology.com/

- The SCSI Trade Association website, which provides information about SCSI standards and terms

  http://www.scsita.org

- IBM Storage media

  http://www.ibm.com/storage/media

- IBM Microelectronics products, including compression devices

  http://www.chips.ibm.com

- Streaming Lossless Compression Algorithm standard from ECMA International

  http://www.ecma-international.org/publications/standards/ECMA-321.HTM

- Tape device driver downloads

  http://www.ibm.com/support/fixcentral/

- IBM Tape Storage Systems

  http://www.ibm.com/systems/storage/tape/

- IBM 3580 Ultrium Tape Drive Firmware

  http://www.ibm.com/support/fixcentral/

- IBM LTO overview

  http://www.ibm.com/systems/storage/tape/lto/

- IBM 3584 drive and library firmware

  http://www.ibm.com/support/fixcentral/

- IBM Sales Manual

  http://www.ibm.com/common/ssi/index.wss

- IBM ServerProven compatibility for hardware, applications, and middleware

  http://www.ibm.com/systems/info/x86servers/serverproven/compat/us/

- IBM System Storage and TotalStorage products

  http://www.ibm.com/systems/storage/product/x.html

- IBM System Storage Interoperation Center (SSIC)

  http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

- IBM LTFS SDE Knowledge Center

  http://ibm.co/1zlag8A

- IBM LTFS LE Knowledge Center

  http://ibm.co/16IkxRQ

- IBM LTFS EE Knowledge Center

  http://ibm.co/16Il4TK
- IBM Tivoli Key Lifecycle Manager

  http://www.ibm.com/software/tivoli/products/key-lifecycle-mgr/

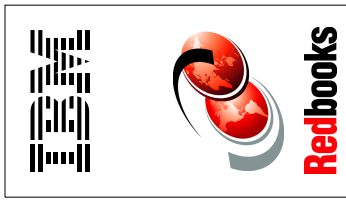
Help from IBM

Help is available from IBM via the following resources:

- IBM Support and downloads

  http://www.ibm.com/support
- IBM Global Services

  http://www.ibm.com/services



IBM Tape Library Guide for Open Systems

(1.0” spine)
0.875”<->1.498”
460 <-> 788 pages

IBM Tape Library Guide for Open Systems



IBM TS1150 enterprise tape drive performance and capacity increases

IBM TS4500, a higher density, next-generation tape library

IBM Ultrium LTO tape drive and library enhancements

This IBM Redbooks publication presents a general introduction to Linear Tape-Open (LTO) technology and the implementation of corresponding IBM products. The high-performance, high-capacity, and cost-effective IBM TS1150 tape drive is included. The book highlights the IBM TS4500 tape library, which is the next-generation storage solution that is designed to help midsize and large enterprises respond to storage challenges.

The IBM TS1150 tape drive gives organizations an easy way to deliver fast access to data, improve security, and provide long-term retention for less expense than disk solutions. TS1150 offers high-performance, flexible data storage with support for data encryption. This fifth-generation drive can help protect investments in tape automation by offering compatibility with existing automation.

This eleventh edition includes information about the latest enhancements to the IBM Ultrium family of tape drives and tape libraries. In particular, it includes details of the latest IBM LTO Ultrium 6 tape drive technology and its implementation in IBM tape libraries. It contains technical information about each IBM tape product for open systems and includes generalized sections about Small Computer System Interface (SCSI) and Fibre Channel connections and multipath architecture configurations. This edition also includes details about Tape System Library Manager (TSLM), which consolidates and simplifies large TS3500 tape library environments, including the IBM Shuttle Complex.

This book also covers tools and techniques for library management. It is for anyone who wants to understand more about IBM tape products and implementation, including IBM clients, IBM Business Partners, IBM specialist sales representatives, and technical specialists.

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